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Lowering the Cost of Corn

ACCORDING to the figures of Dr. J. B. Davidson the investment cost of tractors for growing corn, including depreciation, interest, repair parts, and taxes are or can be less than 50 per cent of the power cost; the power and machinery costs together are only about 20 per cent of the total costs of growing corn; and the total costs of growing corn per bushel and per acre are lowest where modern tractors and operating equipment can be and are used to best advantage. Still these cost items, and the total cost to which they contribute, are subject to further lowering by the application of agricultural engineering.

The direction of its application is in improving machine design; developing machine application principles based on reanalysis of the operations as to their contribution to production and the manner in which those justified may be accomplished with minimum loss of time, motion, and power; and extending these principles to farm practice.

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Labor Saving and Employment

THE sailing ship in which Columbus discovered America is an early example of a labor-saving machine which created employment. Its sails did the work of scores of galley slaves. But it created immediate employment for other sailors by sailing on a new mission. It made possible the discovery of new natural resources which were being used little or not at all. It and later labor-saving developments and applications created millions of jobs in America.

Charles F. Kettering says it takes at least five years for the public to grasp a new idea. The idea that labor-saving devices create employment, however, is a concept which even the American public, with practically all of its jobs created by a succession of labor-saving developments, has not fully grasped after nearly 450 years of varied and repeated affirmative evidence.

Part of the difficulty, we believe, is that the public has not been clearly shown just where and how certain jobs are created or increased by labor-saving on those or other jobs.

Let us grant that the man-hours saved in producing any specific unit of goods are displaced, and are not fully cancelled in advance by the labor used in producing the labor-saving machine involved. Let us grant, too, that labor saving in the production of any necessities for which the demand is relatively fixed decreases the proportion of labor required for such production. And we may further admit that labor saving sometimes makes whole trades and industries obsolete, practically eliminating their labor requirement.

Also let us disillusion ourselves and others as to the practicality of using saved labor to produce more of the same kind of labor-saving machinery to save more labor to use in making more identical machinery, in vicious circles of producing production equipment without regard to effective demand for consumer goods. In effect, the use of much saved labor to produce more labor-saving machinery results in a geometric progression of production capacity which easily outruns the arithmetic progression of consumer demand.

The economic, constructive employment which labor-saving machinery creates is in industries which expand as their products are reduced in cost, and in new products and services made possible directly by labor-saving machinery or indirectly by the release of human energy for professional, scientific, engineering, inventive, and other mental creative work.

A commonly cited example of an industry which has expanded its labor requirements with use of labor-saving machinery is automobile manufacturing. There are numerous others. But the big field of opportunity for labor-saving machinery to create employment is not within the boundaries of any one industry. It is in the unbounded range of possible new industries.

Most of the jobs created by labor-saving machinery bear little resemblance to the jobs absorbed by it. That is one reason why the public has been slow to associate the two. It is a fact to be advanced and explained to the public by the supporters of labor-saving machinery. It creates the problem in human adaptation called technological unemployment, which may be considerably minimized when workers have learned to anticipate it and to prepare themselves for new jobs before the old ones vanish in the path of progress.

These new and different jobs, made possible by labor-saving machines, materialize when men with original ideas and the will to prove them, like Columbus, get venture money from capitalists like Queen Isabella; hire sailors and sail Ninas, Pintas, and Santa Marias, not in old competitive trade channels, but in uncharted seas in search of new trade channels and new resources. We say "new resources" advisedly. The geographic boundaries, materials, and forces of the earth have been pretty well explored, but the resources which those materials and forces represent, in possible new forms and combinations for human use, are still wide open to scientific, engineering, and industrial exploration.

The practice of saving labor began, in fact, with the stone age. From our viewpoint present unemployment is not any indication that civilization should revert to the conditions existing before that time, when man lived by brawn and instinct alone, without the simplest labor-saving tools. Theoretical opponents of labor saving may try that if they like. Nor is present unemployment a true indictment of the practice of labor saving, its instruments, or the men who advance the practice. It is an indication that we are not taking advantage of enough of the opportunities provided by labor-saving to create new and more profitable employment.

War and Agriculture

AS THIS issue goes to press, war in Europe seems imminent. American agriculture is still suffering from the inflation and subsequent deflation of the last major war.

The United States is still in a condition of neutrality and democracy, which permits every citizen to form and express his individual opinion on the policies to be adopted by his country in regard to any war which may develop. To the extent that this country is a true democracy, the majority of opinion thus formulated and expressed becomes the policy of the country. We trust that farmers and the industries serving agriculture will not, in formulating their opinions and contributing to the policies to be adopted by their country, be misled by the memory of two-dollar wheat.

A review of some of the economic factors which may influence agriculture in the event of and following a major war should be sufficient to indicate that American agriculture will not profit from any "blood money" which may get into circulation.

The probable participants have little cash with which to pay for supplies. Any supplies sold to the participants on credit could be paid for by them only by future exports to this country of goods, most of which we do not need and which would represent decreased employment and buying power for American agriculture's chief domestic customer, American labor.

If the United States gets into the war, any resulting inflation will apply to land as much as or even more than to farm products. Land prices will be based on current commodity prices, speculation, and the patriotic urge to produce more and more food, without regard to future real values, land adaptability, or soil conservation. Money will circulate, but farm wealth will decrease rather than increase. Farmers who like to gamble with the odds against them, might better play the ponies or the slot machines;

they could enjoy their losses over a longer period of time and stop them when they wanted to.

And if natural wartime inflation is somehow avoided by regulation, farmers will share the costs without even having been able to enjoy the questionable luxury of a slim hope of individual profit at someone else's expense.

If war comes, American agriculture will be a major factor in maintaining the ideals and independence of this country. It will serve and sacrifice loyally, but it cannot profit. When the war ended, the empty bag held by farmers would not later be filled with two-dollar wheat. Farmers and the industries dependent on agriculture may well take this into consideration in arriving at their individual opinions and contributing to the national policy. Reasons might arise which would justify the United States in participating in the war, but the hope of thus restoring farm prosperity could not be one of them.

Engineering Factors in Farm Management

WHAT can engineers contribute to management, by reason of their special techniques, information, and manner of thought? The question arises because there seems to be a need of clarifying the relationship and opportunities for cooperation between the fields of farm management and agricultural engineering.

Webster's defines farm management specifically as "the phase of agricultural economics dealing with the management of a farm." In more general terms it defines management, in the sense which we believe farm managers use it, as "judicious use of means to accomplish an end." By extension of this latter definition, farm management might be defined more broadly as "judicious use of farm resources in biologic production to provide the means of satisfactory living for the owner, manager, and operator." In other words, our interpretation is that the object of farm management is to get the farm to produce, directly or by exchange, the wherewithal of satisfactory living for those dependent upon it, by means which include satisfactory living and working conditions on the farm.

In defining engineering, Webster's says, in part, "engineering is also applied to the technique of organizing and conducting an industry or an enterprise, and to the technique of exchange of commodities."

From these definitions we conceive that agricultural engineers, by studying the organization and operation of farms, might, in some matters, be able to suggest possible improvements in the techniques for consideration by farm managers and use as they may see fit in advising or directing applications by farm operators.

Obviously agricultural engineering techniques, special information, and methods of thought might have little or nothing to contribute to many of the financial, personnel, and biological problems, for example, with which farm managers are confronted. We do not mean to infer that agricultural engineering encompasses all aspects of farm management. And the fact that some agricultural engineers have, in addition to their engineering proficiency, other abilities and capacities which qualify them for successful farm management, should not confuse the situation.

Some leading farm managers have indicated an active interest in effecting a closer working relationship between the American Society of Agricultural Engineers and the American Society of Farm Managers and Rural Appraisers. We believe that agricultural engineers will have their complete cooperation if we show that agricultural engineers, as a group, have no delusions of taking over the field of farm management, but that we are interested in making available for farm management use and practice in the interest of agriculture, every fact and principle which might be derived from the application of engineering technology to the study of farm operations, farm living facilities, and specific farm management problems.

By way of suggesting some specific phases of farm management on which engineering study might yield profitable information, we refer back to our definition. In the first place, "judicious use" would seem to imply efficiency or effectiveness and conservation in their broadest senses. These are familiar objectives in engineering, as well as in farm management.

"Farm resources" include soil and water, the chemical and physical properties and manipulation of which materially influence farm production and are, likewise, definitely agricultural engineering subject matter.

"Farm resources" include all energy brought to or available for application on the farm in the form of sunlight, heat, animal and manpower, electrical and mechanical power, explosives, and the potential energy stored in fuel. The importance and cost of energy to agriculture demands its effective management. Engineers have studied energy continuously and brought together a great fund of information on its effective application.

Any capital produced on or brought to the farm is a farm resource, subject to management. And capital in the form of materials as such, or combined in structures and equipment as aids to production and satisfactory living, is particularly a matter of engineering concern as to cost, properties, preservation, means of use, and use value.

Biological resources of the farm include all forms of plant and animal life available for use in transforming energy and materials into more valuable forms. The capacities and efficiencies with which these biological resources accomplish this transformation are determined by two factors, heredity and environment.

Modifying and controlling environment is the object of many routine farm operations, from preparing soil for planting to treatment, packaging, and refrigeration of the finished product until it is used or sold. It involves structures and machines, power applications, handling of materials, control of pests and diseases, measurement of quantities and conditions, semi-automatic and automatic devices, air conditioning, and other operations, functions, and controls for giving farm crops and livestock and their products, the most favorable environment for the production desired, so far as it can be provided within economic limits. These are obviously matters in which engineering techniques, equipment, information, and manner of thought can and in fact do result in improved structures, equipment, use methods, principles, and practices available for use by farm managers and operators, for more effectively and economically exercising a measure of control over the environment of biologic production and product handling.

The mutual interest of farm managers and agricultural engineers in safety, sanitation, comfort, and convenience for farm living and working conditions is self-evident, the engineers being professionally concerned primarily with means and principles, and the farm managers with securing their proper application in specific situations.

Consideration is already being given to these matters by both farm managers and agricultural engineers. The point of a closer working relationship and understanding between the groups is that it might easily improve and increase results to the satisfaction of both groups and of farmers generally.

Engineering Indispensable in Agriculture

By E. M. Freeman

AGRICULTURE is the most extensive, as well as the most inclusive, of all human enterprises. It is a trite expression to say that the culture of the land is man's basic occupation. Everyone admits its truth, but very few realize the significance of this truth. It's like saying "good morning"—on an atrociously cold morning. Man is biologically and irrevocably committed to living on as well as off the land.

Agriculture means, of course, the culture or controlled utilization of the soil—in broader interpretation, the earth's solid crust. That soil is not only the largest natural resource of man; it is his most important—his indispensable resource; to man as an agriculturist, it is a trust in perpetuity. His agricultural enterprises, beginning with the raising of a crop and ending with the decay of the mortal remains of the last consumer, restore to the earth in available form the elements agriculture has merely borrowed. "Dust to dust" has agricultural and biological, as well as biblical significance. Gas and gold, on the contrary, are exploitations of the earth's crust which cannot be restored to the earth in that recoverable form in which man first found them. In the future history of man, the pen of evolution will inscribe on the records of geologic ages chiefly man's stewardship of the soil.

By controlling and guiding the flow of rivers, agriculture has made the desert bloom with alfalfa and fruit trees instead of cactus and sage brush. It is a far cry from the pointed stick with which primitive man prepared a seedbed to the gigantic tractor plowing and harrowing and seeding immense tracts of land in a single day. Swamps have been drained, inaccessible areas have been made accessible by good roads, forests are managed with the aid of high-powered machinery, electricity has been used in myriad ways in agricultural service.

Agriculture, however, in actual practice, is not a profession unless we restrict the term to the narrow designation of the man who actually tills the soil. Agriculture is in reality a field of activities, occupations, vocations, and professions as wide and varied almost as are man's fields of knowledge. A college of agriculture, if one is to take that college at its word, should cover a large amount of territory. I can think of only one designation more inclusive and that would have to be a college of civilization. A college of agriculture that actually included in its own walls the teaching and research affecting all of the interests of agriculture would almost engulf the largest university of which it might supposedly be a part.

Colleges and universities are primarily educational devices on a higher level to assist graduates in rendering better service in and to our sociologic order. Actually, and I for one do not imply hereby a criticism, the student goes to college to get a better job, especially in a field in which he is interested. He is realistic about this college business—even as were you and I. But we of maturer years can find a justification of state support for that college training only in the theory and hope that by improving the training, skill, and knowledge of the student not only will that student have a better job but he will contribute to the welfare of our whole social order. The millions of dollars that pour annually into the state-supported colleges pay adequate dividends only when the graduates improve their economic status and also contribute service which shall advance the public welfare in some manner or other.

Colleges of agriculture might be assumed to be responsible for the training of men and women in all of the special fields of knowledge involving agriculture as a public enterprise, including not only the farmer or actual producer of crops, but those specialists in physical, biologic, and social sciences, in engineering, even in business, law, and education, whose services are needed in agriculture. Such a college of agriculture would be almost, if not completely, a university in itself. But the evolution of our higher educational institutions fortunately, I think, has made this unnecessary. While I have dwelt at some length and with positive emphasis on the importance of agriculture to our social order, I am mindful of the fact that agriculture is not the only enterprise of mankind. The arts and letters, education, law, business, engineering, medicine are in their own right vital public enterprises in the growth and maintenance of a higher civilization.

The college student is the raw material to be molded by self-education, assisted by college facilities, such as professors, laboratories, libraries, and what not, into the best professional and citizenship product possible. His by right and not by sufferance are those aids available in any college or department, provided he can use those aids effectively. Nothing irritates me more profoundly than to find in a college catalog a subject matter course labelled "Open only to students in the College of X." I have an almost irresistible desire to persuade some student to register for it, so that I may have the pleasure of helping to batter down the unseemly and unsightly barricade.

Another apparently necessary evil—if evil it be—is the college curriculum. A curriculum to the Romans was either a little car or a small place to run around in, presumably a race track. The latter must have suggested the educational appropriation of the term, since some students run round in college for four years and come out about where they started. Mass college production demands a conveyor-belt type of training for the various professions, and certain essential or key structures may be necessary for that training. These we call required courses. If men were like automobiles, curricula could be specified down to the last subject matter course, even to the exact detail of subject matter accessories in every course. But men are not automobiles. They are individuals and personalities in the exact meaning of those words. Individual differences are not merely the fetish of modern psychologists. They are vital factors in every professional or liberal arts college and in every curriculum.

Many, if not most, educators today will admit that the ideal college would have a separate curriculum for each student, but they say, "Of course, this is impossible in any large college." If you mean by the curriculum only the specified subject matter courses and other required disciplines, this will be true. But I often think that actually we do have individual curricula, "bootlegged" as it were, into and throughout our unsuspecting and formalized higher

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An address before the 32nd annual meeting of the American Society of Agricultural Engineers at St. Paul, Minn., June 21, 1939. Dr. Freeman is dean of the college of agriculture, forestry and home economics, University of Minnesota.

education, because no two students are exactly alike, much as we try to make them so. This vague but tremendously important feature called "personality," about which we talk a lot and do almost nothing, is something that every student must work out for himself, consciously or unconsciously. Even in highly standardized subject matter courses, no two students will carry away with them facts and training identical in amount or in emphasis.

I think this has a good deal to do with engineering, because, first of all, we are all interested in an agricultural engineering curriculum, and such a curriculum is just as important and in some respects more important to agriculture than to engineering. An agricultural engineering curriculum is the business not only of the engineering college but of the college of agriculture as well. That principle has been fully recognized at this institution. Indeed, it was established here by repeated experiences in the building of joint curricula with other cooperating colleges. For instance, agricultural education and home economics education with the College of Education; agricultural business administration with the School of Business Administration; agricultural journalism with the College of Science, Literature, and the Arts (department of journalism); home economics and the Institute of Child Welfare; and finally agricultural engineering with the Institute of Technology. In most of these joint curricula the students are registered, during at least the last two years, in both colleges and are graduated from both colleges.

I come now to the point where I must venture on ground that to me seems less secure to my footing—the field and profession of engineering. I hope you will not think me inhospitably critical if I find fault with your society's definition of the scope and field of engineering—which you define as the control and utilization of nature's forces. I have not found engineers controlling the inheritance of plants and animals; neither are they the investigators of insect pests or fungus diseases of crops and herds, nor dietitians or silviculturists. To me it seems that engineering has primarily to do with the use and control of the physical forces. Physics, chemistry, and mathematics are the basic tools of engineering, just as biology is basic to medicine and animal husbandry, botany to forestry, agronomy and horticulture, psychology to education, and so on. Engineers are professionally trained in the theory and knowledge of the physical sciences, and particularly in the application of those sciences to human needs. That application has a very wide range — the building of dwellings, factories, and churches; the construction of roads, sewers, and bridges; the manufacture of machines for a host of purposes; electrical enterprises innumerable; chemical industries; and the application of physical forces of many kinds in the service of agriculture and industry, and other applications without number. In fact, wherever in our human activities physical force is used or controlled, there is an engineer, professional or amateur.

Agriculture, in contrast, is civilization's trustee of the soil, whose resources can only be made available by the control of physical forces affecting in myriad ways the soil itself, by the control of biologic forces which determine the production and improvement of crops and herds, and finally by the control of sociologic forces, influencing marketing, transportation, distribution, community life, and the whole complex of social conditions. The control of any and all of these forces is of vital importance to agriculture, and engineering is one of the most important means of control. No college of agriculture, unaided, can investigate and teach all of the subject matter, nor can it train adequately for all the vocations and professions involved. It must seek the aid of the most highly trained educational specialists for its agricultural education; it must look to business experts in agricultural business; it must cooperate with the social sciences in the solution of economic, social, and political controls.

Agricultural colleges have been accused, with some measure of justification, as having emphasized production, which is dependent largely on the control of biologic factors, to the exclusion or late development, at least, of the social forces resting on economics, sociology, political science, and history. Agricultural colleges have been, for the most part, schools of applied biology. They must now, perforce, seek more and more assistance in their job of education for agriculture, in the cooperation of other colleges and departments, and even of institutions and organizations outside of our formal college walls.

Engineering is an indispensable profession in agriculture. Every profession must adapt itself to the field of its activities. A profession is a basis for service, not only for personal gain but for the common welfare. An engineer unfamiliar with agriculture's needs and conditions may do agriculture more harm than good. It is quite obvious that engineers operating in the field of agriculture must be agricultural engineers if they are to render the service demanded of them. The fact is, as far as agriculture is concerned, that there are and always have been agricultural engineers, amateur if not professional.

In the training of an agricultural engineer, agriculture has a part and a responsible part. It follows as the day the night that agricultural engineering curricula should be joint enterprises between agriculture and engineering. Agriculture must furnish the agricultural background for effective engineering service. It does not follow that two cooperating colleges or departments have identical shares or responsibility in such training. I am personally of the opinion that in college education the professional training carries the greater responsibility. The agricultural engineer who is not a good engineer is as bad as the engineer who doesn't understand agriculture.

The importance of agricultural engineering to agriculture is by no means confined to the professional curriculum. The control of the physical forces in the service of man's culture of the soil is not the exclusive property of engineers. The farmer, the biologist, the dairy husbandman, the horticulturist, and all the great fraternity of workers in agriculture are at least amateurs in engineering practice. Even I can sharpen a lawn mower—if I have to. In fact, agricultural engineering in this college, at least, did not have its genesis in engineering. It is a child of agriculture. Agricultural engineering began at Minnesota in service courses to students in the School of Agriculture, a secondary vocational preparatory school, training boys exclusively for farming. It developed in agricultural extension services to farmers. It carried on agricultural experiment station investigations for farmers to improve the farmers' engineering practices. With the greater demands for engineering service, it joined with the College of Engineering in an agricultural engineering training on the professional level.

I think, in closing, I express the sentiment of every agricultural college when I welcome you cordially into the great fraternity of professions that serve the great enterprise of agriculture. We want to contribute whatever we have to the training and educational program that will make your profession most effective in our common cause. Together we should be able to make agricultural engineering most effective; we can permeate it with a spirit of public service; we can make it an outstanding branch of the great profession of engineering.

Survey Report on Uses of Electricity in Dairy and Poultry Industries

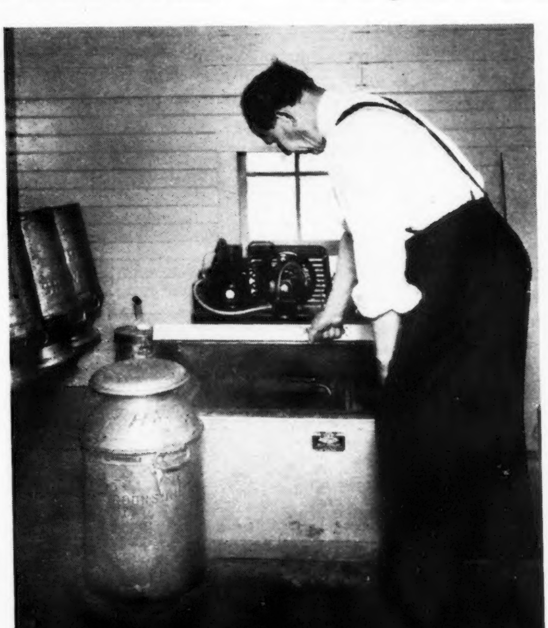
By Harry L. Garver
MEMBER A.S.A.E.

LAST YEAR there was set up in the Bureau of Agricultural Engineering of the U. S. Department of Agriculture a research project in rural electrification. The project as planned was believed to be broad enough to include practical, every-day problems and also studies of a more fundamental nature, the results of which, it is hoped, will have some influence upon the future use of electricity on farms.

The project has as its objective a study of uses that will pay, or at least give promise of paying, their own way and perhaps also net a profit, keeping in mind the low-income farm. As the building of rural power lines reaches the less prosperous farmers, the problem of finding or developing uses of electricity that aid in increasing income gets more and more exacting. Not only must equipment of a readily adaptable and practical nature be developed, but studies must be made which will lay the foundation for developing equipment for the future.

We, who are committed to carry on research in rural electrification, have the responsibility of keeping a jump or two ahead of the desires of farmers if mistakes are to be avoided. This we have in part been able to do. In fact, electrification is one of the few farm developments in which research has kept apace with, if not ahead of, development. Perhaps the fact that there has been so little backing up in rural electrification is due in part to the activities of research agencies. Whether or not research will keep ahead in the future depends on whether properly qualified research workers are provided in sufficient numbers to keep pace with the extension of rural electrification into new areas.

In the Bureau's effort to reach its objective it has set up several goals, the first of which is to survey and collate information on research, both active and completed, on agricultural enterprises in which electricity plays a part. Second, to make case studies of actual farms in various parts of the country and by careful analysis discover how the farm program may make the use of electrical appliances profitable, or, as a corollary to that study, a study of the appliances themselves to see how they may be modified or developed to fit into the present farm scheme in such a way as to make them profitable to the farmer, keeping in mind safety, convenience, beauty, and the fact that we must concern ourselves with the low-income farm. Third, as previously stated, to study the more fundamental problems, such as those relating to the influence of electricity, light, heat, magnetism, and other associated phenomena upon plants and animals.



We have been at this job only since September 1938 and have spent part of the intervening time in perfecting plans and organization for undertaking this ambitious program. Our first efforts were bent in reaching the first goal. This we have partially done, and a start has been made toward the second by making arrangements for cooperative studies with three agricultural experiment stations and starting case studies. The third is, as yet, mostly in the future.

The new project offers something of a challenge. Early investigators, although concerned with the economics of rural electrification, spent the greater part of their time and effort developing new uses and revamping existing equipment to operate with electricity on farms reasonably able to absorb the added expenses. Even here all was not clear sailing. And now, with electricity at the doorstep of folks who at some times of the year wonder from whence the next meal is to come, the problem is more puzzling than ever. Or if, perhaps, the larder may provide salt pork and sow belly, and where pellagra and other dietary disorders are rampant, either through lack of funds or ignorance, how do you and I fit into the picture? What assistance can we give? The problem is in our laps.

Let me go back to the first goal. Between January and May of this year, we have had men whom we borrowed from agricultural colleges visit agricultural experiment stations and collect available data and publications on investigations and research in applications of electricity in the poultry and dairy industries. These men talked to research workers in agricultural engineering, poultry husbandry, and dairying, and also to extension men, gathering from them not only facts about their studies, but statements of their experiences in these studies which are seldom published, but sometimes are of more value than the actual data. From these conversations it was evident that men at the same institution, interested in the same things, were frequently surprised at how much the other fellow knew about his field, also how infrequently

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Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers at Saint Paul, Minn., June 22, 1939. Mr. Garver is agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

many of them pooled their interests and efforts in attempting to reach a solution to a problem.

All too often opinions of two individuals at the same institution were found to be diametrically opposite. Occasionally data could be found to substantiate both arguments. What was the difficulty? To the outsider it looked as though the two had not put their heads together before the experiment started. As long as there is a difference of opinion concerning a problem that lends itself to solution, there is a job for research men, but a look at the field does not suggest a likelihood of research men working themselves out of a job, even if they get together and plan their programs in such a way as to answer the questions without so many ifs or loopholes, as "Under the conditions of the experiment, results were so and so."

We must not conclude from this statement of diverse opinions that there is no agreement on the part of investigators. There is—and lots of it—both on the results of experiments and also on research procedure.

In many institutions two or more divisions get together in planning certain projects. This is a healthy, unselfish, and profitable way to attack a problem. The prejudiced and jealous attitude taken by some departments in planning projects where electricity is involved has left the agricultural engineer in the position of "standing at the station when the train pulled out." Must he push himself into the jam in order to get aboard? It seems that way, at least until he has convinced the other fellow that he has something to contribute. Fortunately, rural electrification men have been able to win the confidence of other divisions and have been accepted on an equal basis with other project directors at many stations.

PRACTICE, PROBLEMS, AND RESEARCH IN SOME SPECIFIC APPLICATIONS

It would be impossible in the short space allotted to this paper to discuss each of the several applications of electricity in either of the poultry or dairy industries. Reference will be made only to some outstanding applications.

Barn Lighting. The one interesting thing about the lighting of dairy barns, in fact, the lighting of all farm buildings aside from the home, is that at least eight states are making recommendations, while only two reported any research done and their studies have been mostly in the use of ultraviolet radiation. Nobody knows just how much light is best for the dairy barn. We assume that it should be sufficient to enable the worker to move about and perform his regular tasks efficiently. Is that all, we may ask? What effect has light on the cow? Would a soothing light encourage her to yield her milk more willingly? What kind of light is soothing to a cow? What, if any, physiological effect does it have?

Wiring. Types of wiring are also recommended without a research background. Several stations have made observations, but no formal research project has been set up as revealed by the survey. One of the interesting things about wiring in particular is that nearly all of the stations are agreed that flexible metal-covered cables should be eliminated from farm building wiring. There is a sympathetic feeling toward the fellow who advocates nonmetallic sheathed cable.

Water Systems. No definite research on water systems was reported, although many states report an extensive use of running water with drinking cups in the barns. Only three, so far as our survey has been tabulated, have shown any hesitancy about recommending drinking cups, and these do not recommend them because of the possibility of freezing and thus causing trouble. The cost is rather high for small dairies and especially so when one cup is provided for each cow. Some states recommend one cup for each two cows, while others believe that this practice is conducive to the spread of diseases.

Warming Drinking Water. Warming of water is definitely recommended by but four of the thirty-seven states visited. Six of the states feel that warming the water has an advantage in that it prevents freezing and that this is perhaps its only advantage.

Milking Machine. One application about which there is a great deal of controversy is the milking machine. The milking machine is extensively used in practically all states visited. The principal objection to the milking machine seems to be that it is unsanitary, not so much in itself, but that it is frequently improperly cleaned and sterilized. Several men hold to the idea that it is responsible for the spread of mastitis, and that, if it is used, it must be used under good supervision. In reviewing the statements brought in by the surveyors, I find but one state definitely recommending the use of the milking machine.

Dairymen have a variety of ideas as to the size of herds necessary for profitable use. The lowest number of cows suggested was eight to ten, while the highest was thirty. The majority of those giving an opinion on this matter stated around fifteen. Portable milkers may be considered as temporary appliances and in most dairies, where milking machines become a part of the regular dairy equipment, pipe-line types are installed. Studies made on the energy requirements of milking machines revealed that 2.93 kwh of electrical energy were used per thousand pounds of milk drawn when the herd consisted of an average of 38.7 cows. In another test of five herds averaging 35 cows each, the energy consumption was 2.56 kwh per cow per month, or 4.5 kwh per thousand pounds of milk.

Feed Grinding and Mixing. Reports of the grinding and mixing of feeds on the farm showed that few states recommend this, and that it is really not being done very generally. Three states have had definite research projects on the problem. In New England, both home grinding and custom grinding by traveling grinders are going out. Where mixing is done, the majority of it is done on the barn floor with a shovel. Farmers don't see the advantage of grinding unless the feed is ground fine, and as a result home grinding is very frequently done too fine. Some states believe there is room for a lot of study on all kinds of feed preparation.

Silo Filling. Many states are cutting silage, but here, too, we see a shift from corn and other materials commonly used for silage to grass silage. The part that the cutting of grass silage will have on the use of electrical power is problematical. The tendency is to favor the use of all-crop machines which chop, crush, or grind the material as it is cut in the field and load it onto wagons, ready for elevating to the silo. Should this practice become popular, a small motor with a drag-type elevator or similar device would be satisfactory for filling the silo, and would probably be used to a considerable extent, because the tractor would be busy in the field. At the present time jobs as heavy as silo filling are done mostly with tractors.

One dairy husbandman believes that we are passing through a revolutionary process in trying to preserve hay crops. Drying, making silage of grass, chopping hay and so on, are but stages in this revolutionary process. There is also need for more knowledge in the handling of molasses.

Hay Chopping. Hay chopping seems to be losing out in some of the states. The greatest advantage in using chopped hay seems to be from the handling standpoint. It

does increase consumption according to the belief of some. The practice of chopping may be justified in the case of high-priced hay. Or where hay may be very scarce, chopping is an advantage, as was the case during the drought of a few years ago. One of the principal difficulties associated with the chopping of hay is that of getting rid of pieces of wire and nails, which, as you well know, are the cause of considerable loss to dairymen. This is a real problem, as expressed by several states. Harrison of New York believes that the chopping of hay makes it less palatable, especially timothy. He also comments that a cow has teeth for the purpose of chewing and has lots of time to chew.

Hay Hoists. There are differences of opinion also on the use of feed handling equipment, hoists, elevators, and so on. The need for hoisting hay will decrease with an increased use of grass silage. Some believe that the cost of the electric power-driven hay hoist is too great and farmers will not pay for it so long as they can hitch a team to the end of a rope, but admit that hay hoists are well liked where they are used. If the use of the pick-up baler becomes more popular it may have some influence on the use of hay-hoisting devices. Not many feed elevators are used, except in the corn belt.

Pasture Irrigation. Pasture irrigation is another application of considerable interest. Very few of the states visited had anything to say about it. However, four of them have actually done some research and believe it may be practiced profitably in certain areas. Wisconsin doubled production, even in a year of abundant rainfall. Another state believes that it has considerable possibilities.

Electric Fence. Most of the states visited have electric fences. Five of them are making definite recommendations. The most useful place for the electric fence, according to these reports, is in the control of pasture rotation, where it seems rapidly to be replacing other types of fence. Ohio reports more inquiries on the electric fence than on any other electrical appliance on the farm. A few dairymen use the device in their barns to prevent "gutter parking."

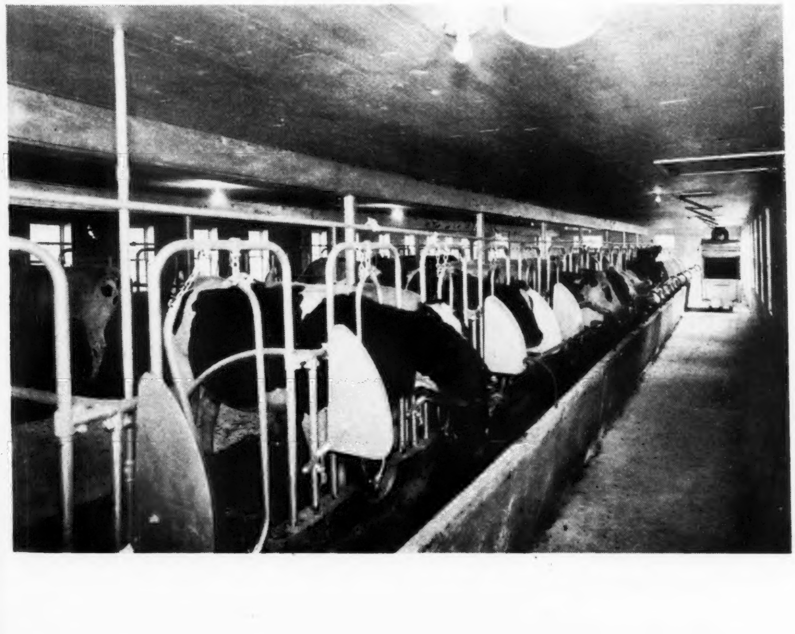
Milk Cooling and Refrigeration. A great many things may be said about refrigeration; in fact, I think more dairy husbandmen and agricultural engineers expressed their opinion on this than on any other application in the dairy industry. The trend in refrigeration is towards commercial units and away from concrete tanks. Sixty to eighty-five per cent of farmers having electricity in the southern states use some type of mechanical refrigeration. Most of the states recommend wet storage. Wholesalers generally use wet storage, while producer-distributors use aerators and dry, walk-in storages.

Not many direct-expansion aerators are used, but there seems to be some shift toward them. Aerators are used principally by producer-distributors and have a very definite place in the cooling of morning milk. An interesting fact about the ordinances of certain states with respect to the use of aerators is that even in neighboring communities some require and some prohibit the use of aerators. This fact leads extension workers and dairymen to wonder if there are not still sufficient problems involved to justify research. This is true not only of aerators, but of the efficiency of cooling tanks with agitators, lengths of coils, and so on. Arguments may be presented to justify the use of any kind of equipment and it is difficult sometimes for us to sort out the points that really are experimental facts from those that are statements designed to stimulate sales.

Records kept in one state show an energy consumption of 1.18 kwh per hundred pounds of milk in wet storage, and 2.5 kwh per hundred pounds of milk when both aerators and dry storage were used. Milk cooled over aerators and sold directly required 0.68 kwh per hundred pounds. No data seem to have been presented which show advantages of brine over "sweet water", or vice versa. Most of the aerators using one or the other do so because of the aggressiveness of the salesman of that area.

As previously stated, most dairymen opened their hearts on this subject and I should like to quote some of them without mentioning their names: "The cooling of milk does not improve but merely aids in retaining quality." "If quality milk is not produced, no amount of refrigeration will improve it." Another statement that was made may be open to challenge, namely, "Farmers produce quality milk to avoid punishment." The statement is also made that "the premium basis is not a satisfactory method of encouraging farmers to produce high-quality milk. It only sets up a standard for a trade area." This same gentleman makes the statement that "aerators are the cheese factories of the farm."

Water Heaters and Sterilizers. Water heaters and sterili-



HOW MUCH LIGHT IS BEST FOR THE DAIRY BARN? IS IT JUST ENOUGH TO ENABLE THE WORKER TO PERFORM HIS TASKS EFFICIENTLY OR DO WAVE LENGTH AND INTENSITY HAVE SOME PHYSIOLOGICAL EFFECT ON THE COW? THESE ARE TYPICAL OF QUESTIONS RAISED BY THE AVAILABILITY OF ELECTRIC POWER FOR USE ON FARMS. ELECTRICITY INTRODUCES NEW FACTORS IN PRODUCTION AND NEW OPERATING CONSIDERATIONS, TO BE EVALUATED BY THE COOPERATIVE RESEARCH OF BIOLOGISTS, FARM MANAGEMENT SPECIALISTS, AND AGRICULTURAL ENGINEERS

zers are usually spoken of as load builders. They are, however, not extensively used and not universally recommended by the extension specialists of the various states visited. Many of the men expressed an opinion that there is a great need for a practical, low-priced sterilizing unit. There is still some question, however, as to the best method of sterilizing. Some states require chemical sterilization. In many parts of the country steam is relied upon for this purpose. Some work is being done with the sterilizing lamp. Regardless of how sterilizing is done, there has been an expression of desire for having it done quickly and easily. There is not much difference north, south, east, or west on the sterilizing situation. In some states household types of water heaters are used for furnishing hot water to the dairy, but in most of the larger dairies steam boilers are used for this purpose. There is still a great deal of room for improvement and education. One problem that has been expressed more than any other is that concerning a rubber that will stand the heat treatment necessary for sterilization. This problem could probably best be worked out in cooperation with one of the concerns manufacturing rubber tubing.

Separating and Churning. It was a surprise to me, having grown up on a farm where we did our own separating and churning, to find so many states where separating is almost a strange word. Many of the states visited had no report on them. Only two states indicated that they were used in any considerable numbers, and five of the states visited said definitely that they were not used to any great extent. The statement was made in Minnesota that they are universal there, while in Wisconsin there are but few used. Michigan states that about 30 per cent of their dairy farms separate milk on the farm.

Churning is very much in the same category. Michigan stated that 0.1 per cent of their farmers do their own churning, while Minnesota also says that churning is negligible. Four only, out of a class of 75 students at the University of Minnesota, reported buttermaking at home. Wisconsin says that churns on the farm are rare. One extension man says that he has not seen a churn on a New Jersey farm in ten years. Pennsylvania farmers, on the other hand, market about one million pounds of butter annually.

A desire is expressed for some research in sonic and supersonic vibrations in certain processes in the dairy industry. Sonic waves, I understand, have some influence on the curd tension of milk. The suggestion is also made that some electrical therapy on cows' udders may have a place on the dairy farm.

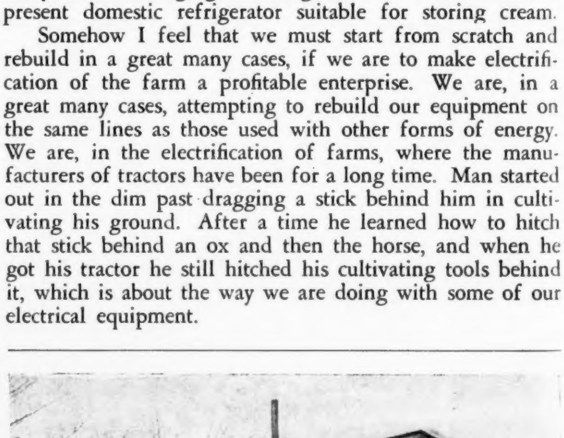
CORRESPONDING PROBLEMS IN THE APPLICATION OF ELECTRICITY TO POULTRY PRODUCTION

Space and time do not permit going into a discussion of applications of electricity on the poultry farm. But in a general way we may say that in the poultry industry as in the dairy industry there are many problems awaiting solution.

One thing that was very definitely pointed out by men at many of the stations visited, particularly the poultrymen, is that we must not delude ourselves into thinking that electricity alone may be credited for advances made in enterprises around the farm for which we rural electrification specialists so frequently push out our chests. Good management plays a big part and the poultryman will tell you so. He will go so far as to tell you that by breeding, selection, choosing correct hatching dates, and with proper feed and care, he can make his hens lay when he wants just as well without lights as with them. Opinions are changing about artificial lights giving hens more time in which to eat, assuming that they will eat more and as a result be forced to lay more. Poultrymen are beginning to believe that light has some sort of stimulating effect on the reproductive organs which causes the hen to lay more, and as a result of greater production she must eat more. It requires no difficult stretch of the imagination to believe that similar stimulation can be effected by feeds and care. We are forced to the place where we must prove that such stimulation can be done more effectively and economically by lighting than it can be done by other means, if lighting of laying houses is going to remain one of the strong selling points in rural electrification. Parallel also with the development of electric brooders has come a greater consciousness of proper care and generally increased intelligence in poultry management. These have had their influence and unless we as research men, leaders in rural electrification, as we are frequently called, are sure of our grounds, we are in a vulnerable spot. If too much is taken for granted, we may some day find ourselves "out on a limb". We may observe what John Jones is doing and write a good story about how he made electricity pay by applying it to a hive of bees, making life around there so uncomfortable for sleeping that even the drones got out and helped make honey. Should it happen that Bill Brown's drones would rather crawl into some hollow tree to sleep, the neighbor who reads the story is going to doubt not only us, but John Jones as well.

Many years are required for the acceptance of new ideas and the adoption of new methods. Naturally there is resistance to the purchase and use of new equipment that requires changes in habits and ideas. Electrification of the farm is no exception to this rule. Let us look at one proposal to change the size and form of the cream can, and see how difficult it would be to change its form. The number of manufacturers concerned with such a change reaches far beyond the ones which make the can. Strainers, racks, truck bodies, washers, sterilizers, and refrigerators may all easily be affected. This question, however, would not necessarily involve changing the refrigerator but would make the present domestic refrigerator suitable for storing cream.

Somehow I feel that we must start from scratch and rebuild in a great many cases, if we are to make electrification of the farm a profitable enterprise. We are, in a great many cases, attempting to rebuild our equipment on the same lines as those used with other forms of energy. We are, in the electrification of farms, where the manufacturers of tractors have been for a long time. Man started out in the dim past dragging a stick behind him in cultivating his ground. After a time he learned how to hitch that stick behind an ox and then the horse, and when he got his tractor he still hitched his cultivating tools behind it, which is about the way we are doing with some of our electrical equipment.



These movable brooder houses at South Dakota State College are now moved by a rubber-tired trailer designed and built by the agricultural engineering department. The work of moving is now greatly reduced and the building is not strained and wracked as was the case when moved by dragging on skids. The mover is easily placed under, and taken from under the houses

Characteristics of Some Meadow Strip Vegetations

By H. L. Cook and F. B. Campbell

AS PART of its comprehensive program of hydraulic research the U. S. Soil Conservation Service is operating an outdoor hydraulic laboratory near Spartanburg, S. C. All research carried out at this laboratory bears directly upon the hydraulic design problems of the field technicians of the Service and is thus of a strictly utilitarian nature. Special emphasis is being placed upon the study of various types of vegetal channel linings. Other important studies are concerned with the development of methods of protecting channels below drops and similar structures, the determination of the capacities of notches in conservation structures, the testing of inexpensive artificial linings, and the study of the hydraulic characteristics of various types of conservation channels. A description of the laboratory appeared in *Civil Engineering* for October 1938.

The tests reported herein were made at the Spartanburg laboratory in the fall and winter of 1937 to determine (1) the effectiveness of three common forage crops in preventing scour in meadow strip and other channels and (2) the water-carrying capacities of channels lined with these vegetations. The kinds of vegetation tested were lespedeza sericea, common lespedeza, and Sudan grass. These crops are often planted in the broad, shallow channels known as meadow strips for the dual purpose of channel protection and hay production. The vegetation was tested the same year it was planted, that is, the test channels represent first-year meadow strips. Further tests have been made of second-year meadow strip vegetations, but the results are not yet available for publication.

Six test channels were constructed for the investigation of meadow strip linings, all identical in cross section, length, slope and in the soil composing their beds. In these channels three types of vegetation were established, each lining being duplicated so that tests might be made of both first and second year meadow strip vegetations.

A summary of the principal characteristics of the channels tested is given below:

Shape:	Trapezoidal
Bottom width:	2 feet
Side slopes:	1 vertical to 3 horizontal
Length:	60 feet
Soil:	Cecil sandy loam topsoil
Slope:	6 per cent
Linings:	Channel No. B2-1, lespedeza sericea
	" " B2-2, common lespedeza
	" " B2-3, Sudan grass
	" " " None (tested bare to provide a basis of comparison)

The channels were excavated in Cecil clay subsoil and lined with typical Cecil sandy loam topsoil hauled from a neighboring field. This topsoil compacted quickly, and at the time of the tests it had attained a density practically identical to that of the undisturbed soil at the site where it was obtained.

The vegetal linings were planted in June 1936 under the supervision of Dr. T. C. Peele of the division of research. Prior to seeding, each channel was treated with lime and fertilizers according to the needs of the particular vegetation to be planted. Every effort was made to obtain a good stand of vegetation. During the dry summer weather the channels were sprinkled. At the time of the tests in the late fall the stand of vegetation in each channel was examined by several Soil Conservation Service agronomists and pronounced "good". Plant counts by quadrats yielded the following data:

Channel	Vegetation	Number of plants per square foot
B2-1	Lespedeza sericea	13
B2-2	Common lespedeza	36
B2-3	Sudan	20

Paper presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, December 1, 1938. Mr. Cook is soil conservationist, section of watershed and hydrologic studies, division of research, and Mr. Campbell was formerly project supervisor, Spartanburg outdoor hydraulic laboratory, division of research, Soil Conservation Service, U. S. Department of Agriculture.

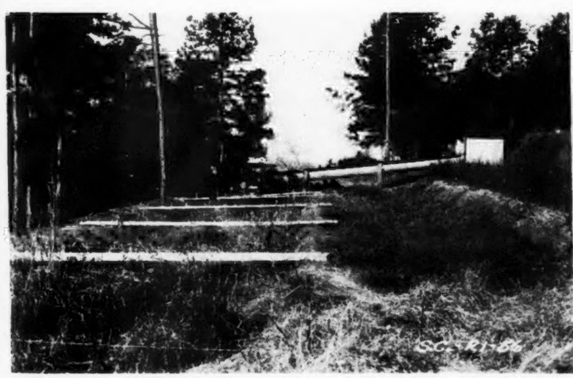


FIG. 1 (LEFT) THE TEST CHANNELS BEFORE THE TESTS — LEFT TO RIGHT, SUDAN GRASS, COMMON LESPEDEZA AND LESPEDEZA SERICEA.
FIG. 2 (RIGHT) SUDAN GRASS CHANNEL UNDERGOING TEST

The tests were made in late November after the plants had become dormant. Fig. 1 shows the channels before the tests, and Fig. 2 shows a test flow passing through the Sudan grass channel.

The test flows were measured by a rectangular sharp-crested weir. The water was conveyed by a masonry supply channel to the site of the experiment and there discharged into the test channels through sheet metal troughs and a movable wooden forebay as shown in Fig. 2.

Transverse profiles of the water surface were made at 10-ft intervals along the channel during each test, and transverse profiles of the bottom of the channels were made at the same sections before and after each test. These measurements permitted the calculation of all of the hydraulic elements of the channel and of the amounts of soil scoured from them.

TABLE 1. SCOUR IN TEST CHANNELS

Channel number	Type of lining	Test number	Flow, cfs	Duration of test, min	Scour, cu ft[a]	Rate of scour, cu ft hr	Mean velocity, fps[b]
B2-1	Lespedeza sericea	1	4.77	51	4.55	5.35	3.11
		2	7.63	45	2.90	3.86	3.55
		4	15.80	52	9.75	11.2	4.46
		5	23.19	40	9.85[c]	14.8[c]	5.21
B2-2	Common lespedeza	1	4.61	35	negligible	—	3.06
		2	7.08	35	"	—	3.55
		3	11.84	44	"	—	4.68
		4	15.28	41	16.75[d]	24.5[d]	5.21
B2-3	Sudan grass	1	4.58	35	3.50	6.00	3.40
		2	7.27	44	0.50	0.68	4.17
		3	11.93	45	1.36	1.81	4.55
		4	15.52	35	7.55	12.9	5.10
B2-3	None (bare)	1	2.93	33	3.25	5.91	6.00
		2	4.75	45	5.95	7.93	6.96
		3	7.56	31	5.10	9.87	7.20
		4	11.42	41	6.60[e]	9.67[e]	8.10

[a]Total scour in two 10-ft reaches—30 ft to 40 ft and 40 ft to 50 ft from head of channel.
[b]Average of mean velocities for the two reaches in which scour was measured.
[c]Bed eroded to underlying stiff clay at a few points.
[d]Test made while the ground was thawing after hard frost; resulting scour should not be compared with measurements on other channels.
[e]Bed eroded to underlying stiff clay over extensive areas; scour not comparable with that for other tests.

Each of the channels was subjected to a series of steady test flows. The tests were separated by intervals of time varying in length from several hours to several days. The duration of the individual tests varied from 31 to 52 min. In the usual series the magnitude of the test flows was progressively increased from less than 5 cfs for the initial test to a flow of 15 cfs or more for the last test. More detailed information on the tests is given in Tables 1 and 2.

Protective Characteristics of Linings. In Table 1 is summarized the results of the scour measurements on the channels.

When different linings are placed in identical channels and subjected to the same rate of flow, the resulting rates of scour can be used as measures of the relative protection afforded. It was intended that all of the tests should be comparable so that the relative effectiveness of the various linings could be determined through a wide range of discharges and velocities. Unfortunately only one set of tests were sufficiently alike to permit of direct comparison. The essential results of these tests are as follows:

Channel	Lining	Test No.	Flow Q	Rate of scour, cfh
B2-1	Lespedeza sericea	2	7.63	3.86
B2-2	Common lespedeza	2	7.08	negligible
B2-3	Sudan grass	2	7.27	0.68
B2-3	None (bare)	3	7.56	9.87

A convenient measure of the relative effectiveness of the vegetal linings is the "protectivity index" calculated by the following expression:

$$\text{Protectivity index} = \frac{\text{Scour in bare channel—scour in lined channel}}{\text{Scour in bare channel}}$$

This index has a value of 1 when the protection is perfect and a value of 0 when no protection is afforded by the lining.

The indices for the one set of directly comparable tests are:

Vegetation	Protectivity Index
Common lespedeza	1–
Sudan grass	0.93
Lespedeza sericea	0.61

These values indicate that, for the particular set of conditions under which the tests were made, common lespedeza and Sudan grass both gave practically perfect protection, while lespedeza sericea afforded only about 60 per cent protection.

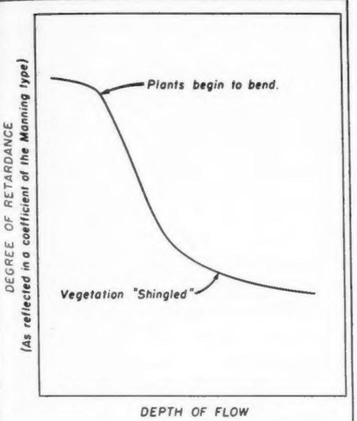
It is obvious that the values of the protectivity index calculated from such scanty data will give only a rough indication of the relative effectiveness of the linings. It is also apparent that the indices would all become smaller under more rigorous tests. They are presented here only for purposes of roughly comparing, or ranking, the linings.

For practical use the engineer must have a measure of protectivity that is expressed directly in terms of some determinable characteristic of the flow. The index most commonly used is that velocity of flow to which the channel may be subjected without suffering any permanently harmful effects. This velocity has been termed variously the "safe", "allowable" or "permissible" velocity. In order to arrive at an estimate of the safe velocity for each of the linings tested, a study was made of the scour data given in Table 1. These data, interpreted in the light of observations made during the tests, seem to indicate that the following velocities can safely be used in design:

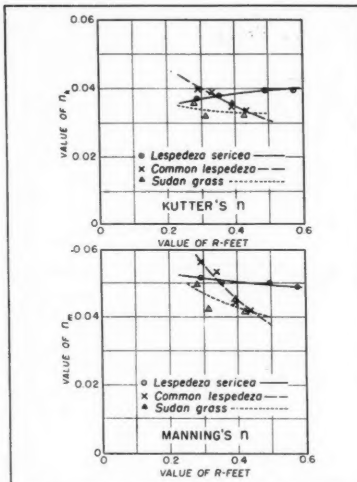
Lining	Probable Safe Velocity, fps*
Sudan grass	5
Common lespedeza	5
Lespedeza sericea	3
None (bare)	1

*Mean velocity determined by dividing rate of flow by the total (gross) cross-sectional area of the stream.

It should be understood that the foregoing safe velocities are recommended only for *good* stands of vegetation subjected to the indicated velocities for only short periods of time. It is assumed, of course, that only intermittent storm flows are to be handled by the channel in which such linings are used, and, moreover, that the short periods of flow are separated by the usual long periods of recovery. Since the vegetation was in a dormant stage at the time of the tests, the recommended safe velocities may be considered conservative if the specified conditions are met. It is quite possible that second-year meadow strips will withstand still higher velocities.



Schematic Diagram Showing How the Retarding Effect Of Pliant Vegetation Decreases with the Depth of Flow in a Given Channel



Variation of Retardance Coefficients with Hydraulic Radius.

FIG. 3 (LEFT) THIS DIAGRAM SHOWS HOW THE RETARDING EFFECT OF PLANT VEGETATION DECREASES WITH THE DEPTH OF FLOW IN A GIVEN CHANNEL. FIG. 4 (RIGHT) THESE DIAGRAMS SHOW THE VARIATION OF RETARDANCE COEFFICIENTS WITH HYDRAULIC RADIUS

Observation of the tests clearly indicated that for channel protection, limber or pliant plants like Sudan possess a marked superiority over stiff or woody stemmed ones, other things being equal. The stiff stemmed plants are not flattened by the flowing water and thus they afford less protection to the channel bed.

Hydraulic Characteristics of Linings. The two formulas most frequently used in the design of open channels are "Kutter" formula:

$$V = \frac{41.65 + \dfrac{0.00281}{S} + \dfrac{1.811}{n_k}}{1 + n_k\left(41.65 + \dfrac{0.00281}{S}\right)} \sqrt{RS}$$

"Manning" formula:

$$V = \frac{1.486}{n_m} R^{2/3} S^{1/2}$$

In these foregoing equations, V is mean velocity in feet per second, R is hydraulic radius in feet, S is slope of channel where flow is uniform (slope of energy grade line where flow is nonuniform), n_k is Kutter's "n", and n_m is Manning's "n".

The terms n_k and n_m in these formulas take into account all factors contributing to the retardance of flow, and, in addition, the departure of the empirical formulas from the true law of flow for the given channel. While they are often called "roughness coefficients", this term does not adequately express their true nature. This is especially true when vegetal channel linings are used, a considerable proportion of the retarding action then being due to the reduction in cross section of the channel. For lack of a better term Kutter's "n" and Manning's "n" will here be called "retardance coefficients".

For each test separate values of n_m and n_k were calculated for each of three ten-foot reaches in the test channels. The means of these three values are given in Table 2, along with the associated hydraulic factors.

An examination of Table 2 will show that (1) in general, the retardance coefficients decrease as the depth of flow increases, and (2) the values of n_m exceed the values of n_k. Some discussion of each of these observations is called for.

Decrease of Retardance Coefficients with Depth. For flows at small depths the percentage of the total cross section occupied by rank vegetation is large. As the depth increases, this percentage becomes less, and the values of the retardance coefficients accordingly become smaller. This effect is independent of the nature of the obstruction and would be found if the individual plants were replaced with rigid replicas. But this is not the only effect present when the obstructions are pliant enough to bend in the manner of plants. An increase in flow produces an increase in both depth and velocity, and this increases the bending moment exerted on the plants. As the flow increases, then, the plants begin to bend, and if the stems are sufficiently pliant, a stage is finally reached at which all of the vegetation is flattened against the bed of the channel. When this occurs the value of the retardance coefficients is strikingly decreased, because (1) the percentage of the cross-sectional area occupied

TABLE 2. SUMMARY OF HYDRAULIC DATA

Channel number	Type of lining	Test number	Flow, Q, cfs	Velocity, V, fps †	Hydraulic radius, R, ft †	Slope* factor, S †	Retardance Coefficients Manning's n_m †	Kutter's n_k †
B2-1	Lespedeza sericea	1	4.77	3.04	.287	.059	.0517	.0371
		2	7.63	3.62	.352	.060	.0502	.0374
		4	15.80	4.53	.492	.061	.0505	.0395
		5	23.19	5.24	.576	.063	.0490	.0395
						Means	(.0493)	(.0377)
B2-2	Common lespedeza	1	4.61	2.94	.288	.065	.0563	.0397
		2	7.08	3.44	.336	.065	.0533	.0389
		3	11.84	4.47	.390	.062	.0445	.0347
		4	15.28	5.12	.433	.064	.0418	.0334
						Means	(.0490)	(.0367)
B2-3	Sudan grass	1	4.58	3.23	.278	.063	.0497	.0358
		2	7.27	3.96	.310	.061	.0426	.0323
		3	11.93	4.31	.392	.060	.0455	.0352
		4	15.52	4.83	.422	.059	.0421	.0335
						Means	(.0449)	(.0342)
B2-3	None (bare)	1	2.93	6.22	.167	.073	.0199	.0167
		2	4.75	7.00	.205	.068	.0191	.0166
		3	7.56	7.10	.277	.058	.0212	.0185
		4	11.42	8.01	.317	.073	.0322	.0201
						Means	(.0208)	(.0180)

*Slope of the energy grade line.

†The numbers in these columns are the means of three separately computed values for three 10-foot reaches; 20′ – 30′, 30′ – 40′, and 40′ – 50′, from head of channel.

by the vegetation is greatly reduced and (2) the hydraulic roughness, or turbulence creating power, of the lining is considerably decreased.

Fig. 3 is a schematic representation of the normal manner in which the retardance coefficient for vegetal linings should be expected to vary with different depths of flow in identical channels.

On Fig. 4 the retardance coefficients of Table 2 have been plotted against the hydraulic radius. Curves to indicate the trend of the values have been drawn in for purposes of illustration. The values of n for the bare channel are not dependable because of the extreme changes in cross section during the tests and for this reason have not been plotted.

A study of Fig. 4 shows that

1 The coefficients for the lespedeza sericea lining vary least. The value of n_m decreases somewhat with increasing depth, while the opposite is true of n_k.

2 Both n_m and n_k decrease with depth in the Sudan grass channel, but the latter changes the least.

3 The retardance coefficients for common lespedeza show the greatest changes with depth.

From the earlier discussion of the nature of the retardance coefficients, it is evident that a decrease with depth of flow is to be expected, especially if the vegetation is flattened by the current. It was observed during the tests that practically all of the sericea plants remained erect. This, in conjunction with the shape of the plants, accounts for the relatively small change in the retardance coefficients for this lining.

Most of the Sudan grass "shingled" at the lowest test flow. For this reason the coefficients are lower than those for the other linings. Probably if the tests had started with lower flows, a portion of the n_m curve for Sudan grass would have fallen more steeply at the smaller values of R.

Common lespedeza plants are not as pliant as Sudan grass and bending was not so complete at the flows used in the tests. In addition the plants were shorter and bushier so that as the greater depths were reached the percentage of the cross section occupied by vegetation decreased rapidly. It is probable that the combination of these two things accounts for the more rapid change in the coefficients for this lining.

Difference Between n_m and n_k. Particular cognizance should be taken of the fact that the values of n_m are considerably larger than the values of n_k. It is often carelessly stated that the Manning and Kutter coefficients are identical. This is strictly true only when the hydraulic radius is 3.28 ft (1 meter). For hydraulic radii less than 3.28 ft the value of n_m exceeds n_k, except in extremely smooth channels. The smaller the hydraulic radii, and the greater the retarding effect of the lining, the greater is the difference between n_m and n_k. This should be kept in mind in choosing values of n for small channels. A comparison of Kutter's n and Manning's n is given in Table 92 of King's "Handbook of Hydraulics" (2nd edition).

Correction of Retardance Coefficients. In any channel lined with rank vegetation "slack-water" or "dead-water" exists near the edges of the stream where the depth is slight. Since a greater percentage of the total cross-sectional area of small channels is taken up by slack-water, it was felt that it might be necessary to modify the values of n derived from the tests when using them for larger channels.

An analysis of the test results using what appeared to be the "net" cross-sectional area of flow instead of the gross area indicates that for very wide channels lined with uncut Sudan grass, the values of the roughness coefficients given above may be reduced by about 5 per cent. From the same study it was concluded that no corresponding reduction need be made for lespedeza sericea or common lespedeza linings.

Machine to Make Rammed-Earth Blocks

A MACHINE which will ram earth into building blocks is reported to have been built by James A. Davis, instructor in blacksmithing, and G. Warren Spaulding, acting superintendent, Haskell Institute, Lawrence, Kans.

This machine is said to put the earth under a pressure of 1200 lb per square inch, and to turn out blocks measuring 8x10x12 in and weighing 65 lb. With a three-man crew it is reported to turn out blocks at the rate of 45 per hour. The machine weighs about 3000 lb, is operated by a 5-hp gasoline engine, and is mounted on a four-wheel, rubber-tired trailer chassis.

In using this machine the earth is mixed with a binder before being rammed.—*Information taken from "Houses 'Dirt Cheap'," by Selma Robinson in the August 1939 issue of "The Rotarian."*

NEW FARM MACHINERY DEVELOPMENTS IN NORTH DAKOTA

(Left) A disk harrow modified for making basins for soil and water conservation. Every other disk is removed and the balance of the blades are cut out as shown and assembled so that the remaining blade portions alternate. (Right) A tractor-mounted, power take-off driven grasshopper bait spreader built by the agricultural engineering department of North Dakota Agricultural College. The operating mechanism is an automobile rear axle assembly with one end of the axle and housing cut off and the bearing reset. The bait tank is an oil barrel. It spreads bait in a 20 to 30-ft strip and can be operated at any speed of the tractor

An Electrical Method for Collecting Semen from Fur-Bearing Animals

By F. W. Duffee
FELLOW A.S.A.E.

FUR FARMING is a large and growing business in Wisconsin and neighboring states, and many farms are in the "big business" class. Among the many problems confronting this industry is that of maintaining high-quality male breeding stock. Foxes are largely monogamous, many large ranches keeping as many males as females. When polygamous mating is practiced, the usual ratio is about one male to three females. Individual cases of polygamous mating of one male to nine or ten females have been secured.

In view of the fact that the pelting season for foxes comes just before the breeding season, it is necessary to keep the males nearly an extra full year, with attendant expense of care and feeding, in addition to the increased investment.

In view of these factors, artificial insemination is highly desirable. This method of breeding would also make it possible to spread rapidly the quality of an exceptional male. It is hoped that artificial insemination will make possible the mating of one male to as many as 50 to 100 females.

The collecting of semen in wild animals cannot be accomplished by any method of interrupting the normal breeding process; therefore, some method of artificial stimulation must be resorted to. One method developed involves electrical stimulation through the proper portion of the nervous system to produce artificial ejaculation. The equipment consists of a high-reactance, leakage type transformer of high voltage and low amperage.

Authorized for first publication in AGRICULTURAL ENGINEERING. Mr. Duffee is professor and head of the agricultural engineering department at the University of Wisconsin.

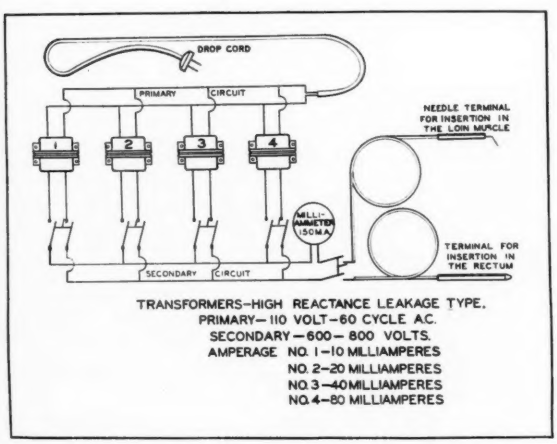


FIG. 1 A UNIT FOR EXPERIMENTAL WORK

With this unit, current values of from 10 to 150 ma can be secured with increments of 10 ma. Example, closing switches 1 and 2 gives 30 ma; closing switches 1 and 3 gives 50 ma; closing 1, 2, and 4 gives 110 ma

WARNING: A current of 100 ma is considered the maximum safe current for human beings that will not cause ventricular fibrillation which will result in almost instantaneous death. This equipment should be used only by those who are thoroughly familiar with its application and potentialities

The effect of electric stimulus is entirely a matter of current or amperage, and for this purpose 0.023 to 0.025 amp (23 to 25 milliamperes) has been found satisfactory on some 40 male foxes.

A high voltage of 600 to 800 volts on the secondary side of the transformer (the side that is connected to the animal) is desirable, as it insures that the desired current stimulus will always be secured, regardless of the body resistance of the animal.

The high-reactance, leakage type transformer is admirably adapted to this work as it is constructed so as to give a definite and limited amount of current on a dead-short connection. In practice the current passing through the animal is only one or two milliamperes less than the dead-short reading. Thus, when a transformer with an open-circuit voltage on the secondary side of 600 volts, and a dead-short reading of 0.025 amps (25 ma) is used, the amount of current that will pass through the animal will be 0.023 to 0.024 amps (23 to 24 ma) under ordinary conditions, and under no condition, barring tampering with the transformer, can more than 0.025 amps pass through the animal's body.

The method of procedure is to insert one of the secondary terminals about 3 in in the rectum; the other terminal which is fitted with a needle is inserted about 1/4 to 1/2 in in the loin muscle to one side of the spinal column, and opposite the junction of the second and third lumbar vertebrae. This is inserted through the skin and into the muscle a short distance but not far enough to touch the bone. A double-pole switch installed in the secondary circuit is used to close the circuit, and series of 7 to 11 impulses or stimuli are administered, depending upon the animal's reaction. The electrical stimulation consists of closing the switch, giving an "on" period of about three seconds, and then opening it or providing an "off" period of about two seconds.

A successful technique was not developed until the breeding season for foxes was about over for the past season; therefore, no data relative to artificial insemination

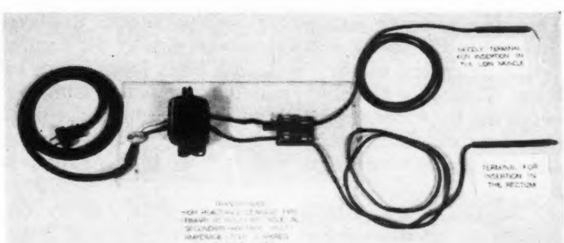


Fig. 2 A simple unit suitable for use in collecting semen from foxes. A milliammeter installed in the secondary or animal circuit would be desirable. This unit should deliver 0.025 amp (25 ma) on a dead short

are available. However, the artificial ejaculation has been very uniform, and microscopic examination of the semen indicates a high quality.

Currents considerably in excess of the specified 0.025 amps have never caused death or any visible harmful effects upon the foxes. It is likely that this amount of current could cause death in a fox if it were administered without interruptions for several minutes, and further if the path of the current were changed to some other part of the body.

WARNING: *The use of electric current in such quantities as suggested here involves some elements of danger to the operator. Great care should be exercised that the operator does not get in the path of the current. A current of 0.025 amps (25 ma) will cause violent contractions of the muscles. A terminal grasped in the hand could not be released. This amount of current or slightly more passing through the skeletal muscles would stop breathing, and if continued would cause death due to suffocation. A current of 0.1 amp (100 ma) is considered the maximum safe current for human beings that will not cause ventricular fibrillation, which will result in instantaneous death.*

This equipment should be used only by those who are thoroughly familiar with the principles involved and the potentialities of the equipment.

Those who are not informed on the subject of electric shock and who expect to use this equipment would do well to study an article, entitled: "Effect of Electric Shock on the Heart", by Ferris, King, Spence, and Williams, published in "Electrical Engineering" for May 1936.

The technique has been developed so far for foxes only. This work is a joint research project at the University of Wisconsin with the departments of agricultural engineering, biology, genetics, and veterinary science cooperating, and is a part of the project on the endocrine relations of furbearing animals.

AUTHOR'S NOTE: Acknowledgment is hereby given to the assistance of the following cooperators on this project: S. H. Barker, H. D. Bruhn, L. E. Casida, R. K. Meyer, and Walter Wisnicky.

Electric Light in Plant Production

DURING THE past year the two things which seem to have created the widest interest in connection with light and plant growth are as follows:

1 The new fluorescent tubes that have approximately doubled the efficiency of tungsten filament lamps and emit about one-quarter the amount of infrared, or heat, radiation per foot-candle. These tubes are available in various colors, but those emitting daylight quality of light are proving the most successful for plant growth. The green tubes, on account of their very high efficiency—60 lumens per watt—look promising, and several plant research institutions are now testing them.

2 The increasing interest in the use of nutrient solutions has naturally created requests for data pertaining to the use of artificial light. In general, experience seems to indicate that about the same lighting technique as applied to soil culture can be used with chemiculture.

The University of California has combined the use of liquid nutrients and daylight fluorescent lamps in their exhibit of indoor-grown tomatoes at the San Francisco Fair.

From the Mistaire Laboratories at Milburn, New Jersey, comes word of an interesting method of growing plants for research purposes in jellied chemicals and the use of heat-absorbing glass to lower the temperature in sunlight.

During the year there has been a rapid increase in the use of incandescent lamps for drying paints, lacquers, etc. Their advantage over other lower-temperature sources of heat is that the infrared radiation from these lamps penetrates more deeply and does a much quicker drying job. This same principle, though for another purpose, has been tried out in California with apparently considerable success, in the protection of the citrus fruit trees from injury by frost. The radiant energy from rows of lamps hung between the trees seems to do a better job than smudge pots, large fans, etc. Research is now under way to determine the exact range of wave length that is most effective for this purpose.

There has been considerable interest created by the appearance on the market of a so-called infrared insect killer. This consists essentially of an incandescent lamp of about 350 watts rating, an asbestos-lined holder equipped with a handle for the bulb, a cord, switch, and plug. The lamp bulb is silvered, and so shaped that the energy is concentrated into a spot approximately 4 in in diameter about 10 in from the unit. It is claimed that the infrared energy from this unit will kill insects on animals and plants. Tests indicate that it is extremely difficult to kill plant pests without burning the plants.

During the year three new sources of short-wave, ultraviolet radiation, a 15-watt tube, a 5-watt tube, and a 3-watt tube have been made available. Approximately ninety-five per cent of the ultraviolet output of these lamps is at 2537 Angstrom units wave-length. This radiation is strongly germicidal and very effective for sterilization purposes. Since the 15-watt tubes are relatively inexpensive and will operate in the standard equipment used with 15-watt fluorescent tubes, it is likely that they will find uses in the horticultural field.

Several reports and publications have come to the attention of the Committee during the year, as follows:

The Role of Light in the Life of Plants, by Paul R. Burkholder. Bot. Rev. Vol. 2, No. 1, Jan. 1936; and Vol. 2, No. 3, Mar. 1936.

Correlative Effects of Environmental Factors on Photoperiodism, by K. C. Hammer. Bot. Gaz. 99. No. 3, p. 615-629, 1938.

Biological Effects of Radiation, by Benjamin M. Duggar. Vol. I and II. McGraw-Hill Book Co., N. Y. 1936.

Influence of Different Periods of Artificial Illumination on Flowering of Asters. Forty-Eighth Annual Report of Agricultural Experiment Station, Alabama Polytechnic Institute.

Preliminary Report on the Use of Lights in Retarding the Blooming Period of Chrysanthemums, by F. S. Batson, Mississippi State College. Supplemental light with 100-watt Mazda lamps, 75 footcandles on plants, 3 hours daily for 8 weeks retarded blooming 6 weeks. Also effective retardation with 2 footcandles.

Special Circular No. 54, Sept. 1938, Ohio Agricultural Experiment Station, Wooster, Ohio. Lighting greenhouse grown tomatoes and forcing gardenias with artificial light.

Setting Tomato Buds, by Dr. I. C. Hoffman, Wooster, Ohio.

Effects of Ultraviolet Radiation upon Germination and Seedling Development, by H. W. Popp. Bulletin 366, May 1938, Pennsylvania State College, School of Agriculture and Experiment Station, State College, Pennsylvania.

The Water-Culture Method for Growing Plants without Soil, by D. R. Hoagland and D. I. Arnon. Circular 347, Dec. 1938. University of California Agricultural Experiment Station, Berkeley, California.

A contribution of the A.S.A.E. Committee on Electric Light in Plant Production, I. P. Blauser, N. D. Herrick, L. C. Moore, M. W. Nixon, L. C. Porter (chairman), J. P. Schaenzer, and J. R. Tavernetti. Received June 1939.

Power Equipment for Injecting Carbon Bisulfide into Soil

By Orval C. French
MEMBER A.S.A.E.

CARBON bisulfide (CS_2) is a clear, volatile liquid that vaporizes readily to give an extremely toxic gas which is heavier than air. When injected into the soil and sealed in to prevent excessive loss, it kills all plant roots as well as fungi that are within the treated soil mass. This material has the advantage of leaving the soil within a few weeks' time so that upon tillage and aeration of the soil crops can again be grown.

California farmers are using CS_2 in increasing quantities for control of rodents, noxious weeds such as wild morning glory, and certain fungus diseases. One disease in particular, known as oak root fungus (also known as fungus root rot and mushroom root rot) is a serious menace to fruit and nut trees as well as shade trees and ornamental shrubbery.

Released for first publication in AGRICULTURAL ENGINEERING. Mr. French is instructor in agricultural engineering and junior agricultural engineer in the experiment station, University of California.

The only successful control for oak root fungus at the present time is with CS_2. Experimental work has demonstrated that for control of oak root fungus and noxious weeds, best results have been obtained by applying 2 fluid ounces (60 cc approx.) in holes in the soil 18 in apart throughout the area being treated. The depth of application depends on soil conditions such as moisture and tilth, and for weeds the depth depends somewhat on the root system. For shallow root systems the CS_2 is applied shallow.

Up to the present time practically all CS_2 has been applied by hand labor, using some form of hand applicators, of which there are several types available. This method is tedious but practicable for small areas. Several power applicators have been built but have proved only partially successful.

One type of power applicator that has been more generally used in California than any other consists of a heavy-duty chisel cultivator having three chisel standards mounted 18 in apart. On top of this chisel frame is a 50-gal drum

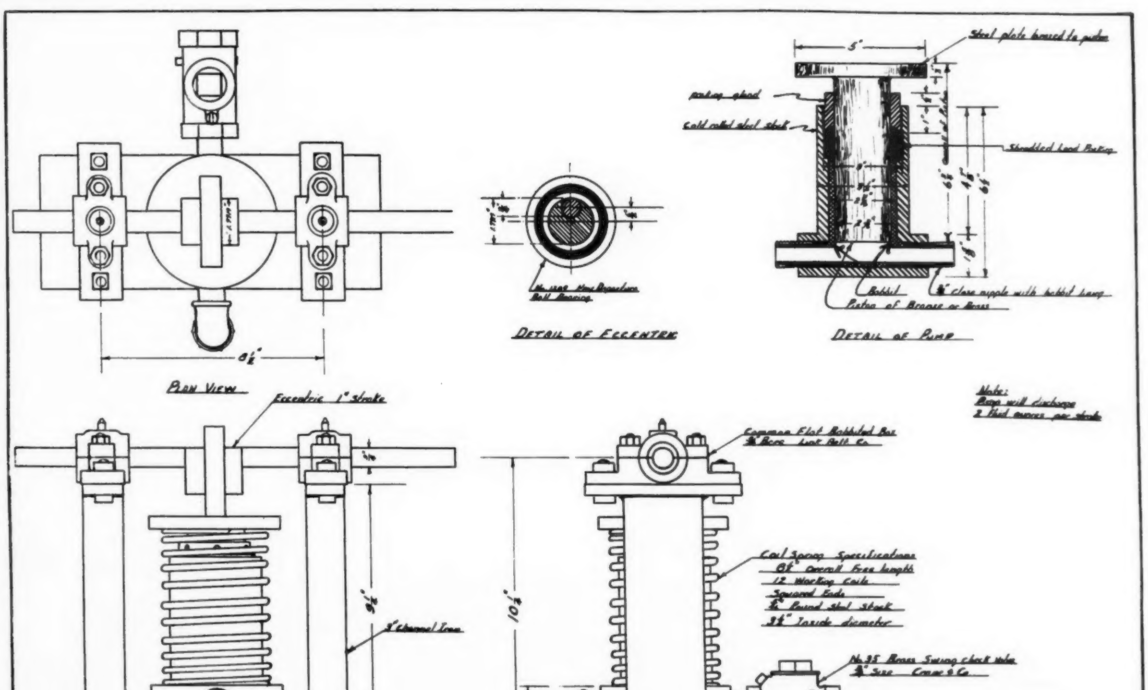


FIG. 1 DETAILS OF THE CALIFORNIA EXPERIMENTAL CARBON BISULFIDE PUMP

which is connected by means of a manifold system of piping to three ball type valves that are mechanically operated by cams. When the cams open the valves, CS_2 flows by gravity from the drum through the valves into boots that are part of the chisel standards. The cams are chain driven from the ground wheel of the chisel at a speed sufficient to allow them to open the valves once for every 18 in of forward travel.

One can readily understand that the quantity of material discharged by such a metering device will vary as the height of CS_2 in the supply drum changes, as well as with a change in forward speed of the unit. Furthermore, if forward motion ceases while a cam is holding a valve open, the liquid will continue to flow from the valve. Occasionally sparks caused by contact of the standards with stones in the soil ignite the CS_2, causing fires within the boots. For these various reasons it was deemed desirable to design an improved applicator. A study of the requirements for successful machine application of carbon bisulfide led to the following conclusions:

1 The CS_2 has to be positively injected into the soil at 18-in intervals in each direction.

2 Two fluid ounces per discharge are required, and this quantity should remain constant even though the rate of forward speed of the applicator changes.

3 Elimination of wetting chisel standards or boots by CS_2 is essential.

These requirements immediately suggest the use of a positive displacement type of pump. Since a commercially available pump of this kind and size could not be found, and manufacturers of pump diaphragm material had nothing to offer capable of resisting the solvent action of CS_2, the author has designed and constructed one that will meter small quantities of CS_2 and also withstand the deteriorating effects of this chemical. This pump is illustrated in detail in Fig. 1.

Owing to the non-lubricating properties of CS_2 and also the fact that it is a solvent for most lubricants, a piston with rings for a seal was avoided. A plunger with leather cups was likewise not considered, because CS_2 rapidly deteriorates leather. The simple displacement pump with finely shredded lead outside packing was the choice for this problem. The use of a bronze plunger and babbit-lined cylinder provides wearing surfaces that effectively resist corrosion from impurities that may be present in CS_2. Actuation of the plunger by means of an eccentric and coil compression spring is one of the simplest systems of reciprocating motion, yet very desirable because it eliminates side wall pressure on the cylinder and packing.

The experimental pump was connected to a drum of CS_2 so that when under test the liquid was merely recirculated. Power for driving the pump was supplied by an electric motor through a variable-speed transmission in order that many different speeds could be quickly obtained. The testing procedure was to run the pump at various intervals of time, allowing it to remain idle between runs with no effort to flush out the system after each run. Over a period of three months the pump operated 200 hours, requiring no servicing other than an occasional tightening of the packing nut. Apparently the freedom from corrosion and "freezing" of the pump and valves can be explained by the fact that the CS_2 was confined in practically a closed system so that very little oxidation occurred.

The results obtained from testing the experimental pump encouraged Wheeler, Reynolds, and Stauffer, manufacturers and distributors of CS_2, to build a field machine using three very similar pumps to meter and inject CS_2 into soil. Their pumps differ from the experimental pump only in that better quality valves were used. Horizontal poppet type check valves with stainless steel seats and disks were installed, with spring-loaded discharge valves, requiring approximately 10 lb per sq in pressure to open.

The details of the new power applicator are shown in Fig. 2. The vehicle for this unit is a Towner heavy-duty field chisel cultivator. Three chisel standards are placed 18 in apart with the center standard set forward for more clearance. Boots welded on the back of these standards protect the ¼-in discharge pipes that carry the CS_2 from the discharge valves. The discharge pipes extend to the lower edge of the boots and bend slightly at the lower end to direct the CS_2 back from the standard in order to eliminate any CS_2 collecting on the bottom of the standard. This reduces the chances for fires. The pumps are driven by a chain drive from the ground wheel through a jaw clutch at a speed that permits the pumps to discharge once for every 18 in of forward travel. The two supply tanks of 25 gal each are mounted slightly ahead of the power-lift axle in order to balance up the load on the chisel frame. Because the power-lift mechanism is located in the center of the tool and a capacity of 50 gal was desired, two tanks were used. Fifty gallons of carbon bisulfide weigh 525 lb, so the location of the supply tank is important. The tanks are provided with drain sumps to which a manifold piping system is connected. The elevation of the tanks is such that CS_2 flows into the intake of the pumps under some pressure which permits the pumps to operate at very high volumetric efficiency.

The general procedure in the use of this equipment is to prepare land about as would be necessary for an ideal seedbed. The moisture content (Continued on page 358)

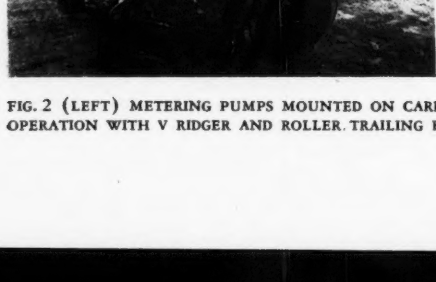
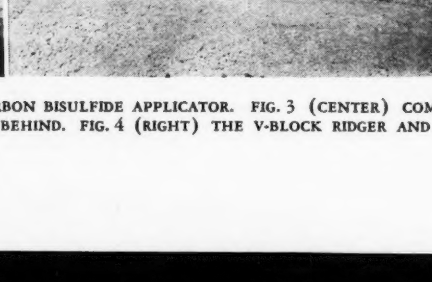
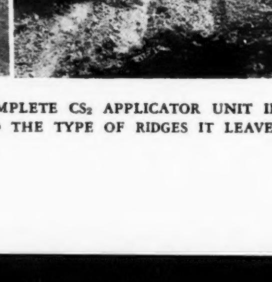




FIG. 2 (LEFT) METERING PUMPS MOUNTED ON CARBON BISULFIDE APPLICATOR. FIG. 3 (CENTER) COMPLETE CS_2 APPLICATOR UNIT IN OPERATION WITH V RIDGER AND ROLLER TRAILING BEHIND. FIG. 4 (RIGHT) THE V-BLOCK RIDGER AND THE TYPE OF RIDGES IT LEAVES

Condensation Problems in Farm Buildings

By L. V. Teesdale

CONDENSATION of moisture in farm buildings housing livestock has always been a problem in the winter in the colder portions of the country, and is responsible for much of the maintenance expense on these structures. This problem is not peculiar to farm buildings, but occurs in varying degrees of importance in houses, factories, creameries, cold storage warehouses, freight cars, and even in air-conditioned railway coaches. For each type of occupancy or condition there is, of course, some method of control or prevention, sometimes simple, sometimes complex. In houses under construction it is relatively simple and inexpensive to include vapor barriers that will control the condensation problem to a satisfactory degree. Methods applicable to one type of occupancy do not necessarily fit other types. Consequently, each type must be considered separately and methods of control developed suited to the conditions involved.

A certain amount of water vapor is always present in the atmosphere. The maximum amount of water vapor that can be present depends upon the temperature of the air, being greater at higher temperatures. By definition, air that is completely saturated with water vapor is at its dewpoint temperature, and its relative humidity is 100 per cent. Air not completely saturated with water vapor is above its dewpoint temperature and its relative humidity is less than 100 per cent. Adding water vapor to unsaturated air without changing the temperature of the air will increase the relative humidity and raise the dewpoint temperature. Removing water vapor will have the opposite effect. Raising the temperature of air without changing the amount of water vapor in it will decrease its relative humidity. Lowering the temperature without changing the amount of water vapor will increase the relative humidity till the dewpoint temperature and saturation are reached. Further lowering of the temperature will cause progressive condensation of water vapor from the air.

The use of relative humidity as a measure of the amount of water vapor present in a given atmosphere is not satisfactory because this relationship varies with the temperature. Hence it is more practical to use the vapor pressure of the water vapor for this purpose, since it is a direct measure of the amount of vapor present in the air. This property is usually expressed in terms of inches of mercury.

At 0 F (degrees Fahrenheit) air will hold very little water vapor. If saturated air from out of doors at this temperature be introduced into a barn, without adding moisture, and raised to 45 F, its relative humidity would be about 13 per cent. If there was no source of moisture present within the barn, the vapor pressure inside would be equal to that out of doors. However, in dairy barns, for example, the animals supply a large amount of water vapor to the air by transpiration and exhalation, and there are numerous other sources such as manure, urine, drinking water, and feed. Actually the humidity in a tight barn may be and usually is very high during cold weather. It has been estimated that a milch cow of average weight will give off 12 to 18 lb of moisture per day, an average of 4.375 grains per hour. At 45 F, saturated air will hold only about 3½ grains of water vapor per cubic foot. A few cows would, therefore, very quickly saturate the air in a barn if there were no means of escape for the moisture, and if this temperature were maintained. However, with a higher temperature and a higher vapor pressure in the building than outside, vapor escapes outward through cracks and crevices, by direct ventilation, and to some degree by passing through the walls of the structure. Furthermore, in the colder weather, vapor may condense as liquid water or as frost upon and within the walls and ceiling. When, at constant temperature within the building, the losses described equal the supply, the internal relative humidity remains constant; but if the supply exceeds the losses, the relative humidity approaches saturation.

The principle of ventilation as a means of removing the vapor is well understood, and barns generally are provided with some form of ventilating system, not only to remove the vapor but also to purify the air. Provision for ventilation varies widely, being sometimes limited to cracks and crevices, sometimes to a roof vent over the hay mow, but in the better types of modern barns inlet and outlet flues and ducts, including dampers for control, are provided. During most of the year, including the milder winter weather, ventilation can be counted upon to keep the barn normally dry. During cold weather the problem becomes complicated by the fact that the ventilation must be reduced to prevent the barns from becoming too cold; at the same

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., November 30, 1938. Mr. Teesdale is senior engineer, Forest Products Laboratory, U. S. Department of Agriculture.

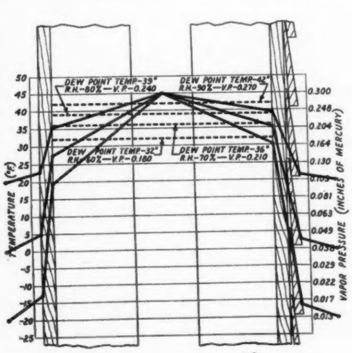


FIG. 1

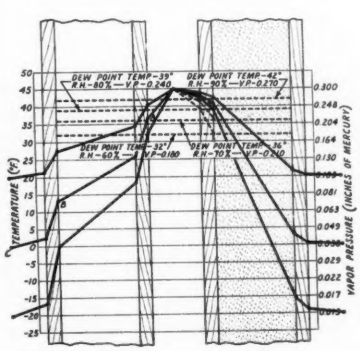


FIG. 2

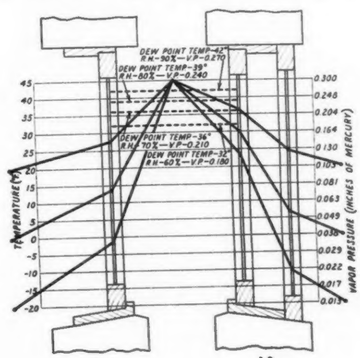


FIG. 3

time windows, exterior walls, ceilings, and roof surfaces become colder and act as condensing surfaces. Condensation develops on surfaces that are below the dewpoint of the atmosphere and since the humidity in stock barns is quite high, a surface that is only a few degrees colder than the atmosphere may be below the dewpoint. For example, at 45 F and 90 per cent relative humidity the dewpoint is about 42 F. Should any portion of the walls, ceilings, roof, or glass surface be below 42 F condensation would develop on such surfaces. Since the animals furnish the source of heat and since a large part of the heat lost is radiated through the surfaces mentioned, these surfaces are bound to have a lower temperature during cold weather than the general barn temperature. The effect of the humidity or vapor pressure on condensation may be understood by examining Figs. 1, 2, and 3. Frame walls have been selected for examples, but the same principles apply to masonry and steel construction. In Figs. 1, 2, and 3, 1A illustrates a typical frame wall of a barn having vertical or drop siding only, 1B a wall with sheathing and siding, 2A a wall with siding and lined on the inside, 2B the same type of wall filled with commercial insulation, while 3A illustrates the temperature gradients through a single window, and 3B a window and storm sash.

For purposes of illustration only one interior temperature (45 F) has been used and the temperature gradients calculated for three outdoor temperatures, 20 F, 0 F, and −20 F; four relative humidity conditions are illustrated by showing the dewpoint temperatures for 90, 80, 70, and 60 per cent relative humidity. The water vapor pressures corresponding to these dewpoints are also marked on the respective lines. Saturated vapor pressures corresponding to the temperatures shown are given on the right-hand scale.

When the temperature on the inner face of the wall is above the dewpoint temperature in the room no condensation will take place on that surface, but when it falls below the dewpoint, condensation may occur. Note in wall 1A that even with a temperature of 20 F outdoors the temperature of the inner face of the wall practically coincides with the dewpoint temperature for 70 per cent relative humidity, and should the relative humidity be above 70 per cent, condensation could develop. Since wood is permeable to water vapor there will be some out leakage, thus producing a vapor pressure gradient in the barn, and condensation will take place on the inner surface when that surface has a temperature somewhat below the dewpoint temperature within the main body of the barn. If the surface were impermeable to vapor, condensation would occur at that dewpoint temperature. Paint on the exterior would retard the passage of vapor, some kinds of paint more than others and new paint more than old paint. Water below a paint film is liable to cause paint failure.

The inside wall face temperatures on wall 1B are somewhat higher than 1A and this reduces somewhat the tendency for condensation to appear on the inner face of the wall. However, should a vapor-resistant sheathing paper be used between sheathing and siding, vapor passing through the sheathing would, under the stated conditions, condense on the sheathing side of the paper. The temperatures on the inner surface of wall 2A are slightly higher than for 1B. An analysis of this 2A wall shows that at 70 per cent relative humidity inside there would be no condensation on the inner face of the wall when the outside temperature was zero. Assuming that the permeability of the inner lining and outer sheathing were equal, it might also be assumed that vapor passing through the inner lining would also pass at the same rate through the outer sheathing. However, conditions are complicated by the differences in vapor pressure on opposite sides of these surfaces and by condensation. Since the rate of movement is a function of the difference in vapor pressure, other factors being equal, vapor will move fastest when the greatest difference in pressure exists.

At 45 F and 70 per cent relative humidity within the barn, 0 F and 100 per cent relative humidity outdoors, the vapor pressure at the inner surface of the wall lining at point A would be about 0.210 in of mercury, at the inner surface of the sheathing at point B about 0.073, and outside at point C about 0.038. Since the difference between B and C is 0.035 and between A and B 0.137, and since condensation would occur at B, the vapor movement from A to B would greatly exceed that from B to C. As the temperature at that point is below freezing, the condensation would appear as frost or ice.

The same general principle of vapor movement exists in the insulated wall, 2B. Note that the inner surface of the wall is above the dewpoint for humidities of 90 per cent or lower, even in the coldest weather. Of course, the resistance to heat loss offered by the insulation results in a lower temperature at the sheathing line, consequently the sheathing is below the dewpoint at somewhat higher outside temperatures than is the case with uninsulated walls. This fact in turn increases the amount of condensation that may collect, since it materially increases the time during which conditions are favorable for condensation. Insulation does not "draw water" as is sometimes suggested, but, because of its efficiency in reducing heat loss, lowers the temperature within the walls and thus sets up the condition that increases the amount that may collect. Some kinds of insulation are relatively resistant to water absorption, others are treated to make them resistant to wetting by water. This property, while desirable, does not make these materials resistant to the passage of water vapor. Therefore, they should not be considered a source of protection against condensation. Ice that gathers in cold weather will melt in subsequent mild weather and then the water can back up into the insulation. While certain types of fill insulation are not hygroscopic, water can collect in the interstices.

As a rule, the windows and doors are the first place to show evidence of condensation. Glass is a good conductor of heat, consequently the inner surface of a single pane will invariably be at a lower temperature than the inner surfaces of the walls of the barn. This may be illustrated by comparing the temperature at the glass line, wall 3A, with the inner surfaces of the wall types shown. Even with double glazing or storm sash as shown in 3B, the inner glass surface is at a lower temperature than 1A. Since glass is not permeable to water vapor, there can be no leakage through it, but some vapor will escape through cracks and crevices around the inner sash into the space between the two sash, and unless vented to the outside will appear as condensation on the inner surface of the outer glass. Sun shining on a glass surface may melt the accumulated frost, but more frost gathers as soon as the effect of the sun is removed. Repeated wetting and freezing is bad for any type of window.

Conditions that cause condensation in side walls also occur at other places in the structure—on the ceiling, on the under side of the roof, and even in the ventilators. The hay mow over a cow barn should be dry, but if vapor can leak through the floor and escape through openings into this space, condensation will follow unless the moisture can be removed by ventilation.

The movement of water vapor is independent of air movement to the degree that no general circulation is necessary to carry the vapor from its source to the condensing surface. The vapor actually moves by diffusion from sources

of higher vapor pressure to zones of lower vapor pressure. Any air movement will, of course, tend to speed up the diffusion and equalization of vapor pressure.

The amount and location of condensation within the walls of stock barns and on the wall surfaces are affected by five factors:

1 Outdoor temperature and humidity
2 Thermal efficiency of the wall
3 Indoor temperature and humidity
4 Resistance of outer wall to vapor movement
5 Resistance of the inner wall to vapor movement.

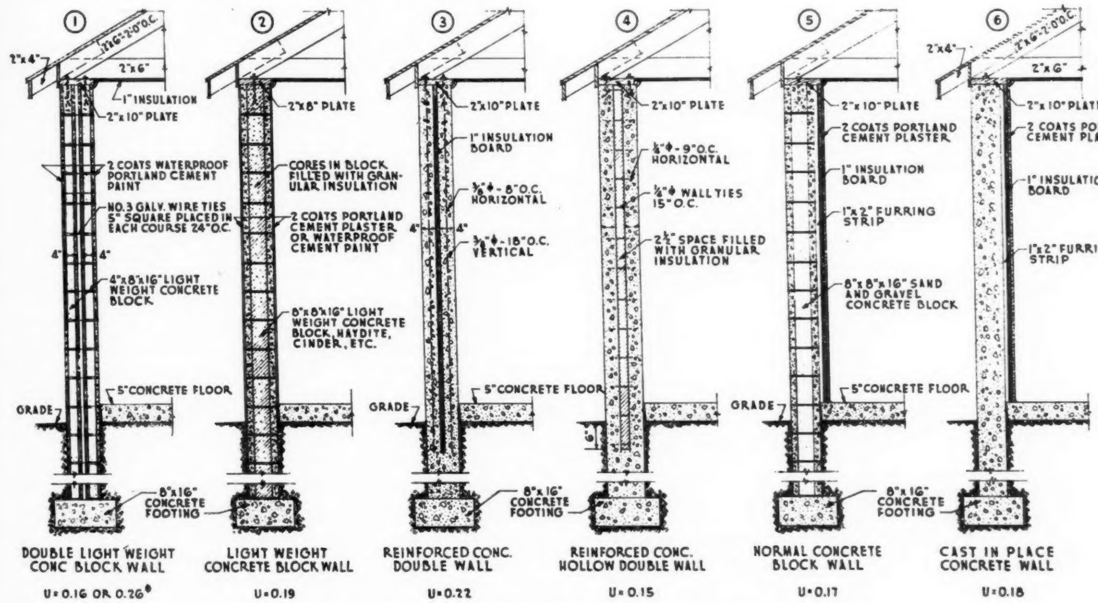
To prevent or to minimize condensation it is necessary to bring certain of these factors under some degree of control. As the outdoor temperature and humidity cannot be controlled, all possible methods of prevention are limited to the other factors.

Since it is the artificial increase in the humidity in the barn that creates the conditions causing condensation, obviously all possible means of maintaining lower indoor humidities should be considered. Ventilation is the most practical method of lowering the humidity, but because it lowers the temperature as well it has its limitations. Preheating the air used for ventilation would make it possible to control the humidity more or less as desired. It would also have the advantage that a smaller amount of air would serve to keep the humidity down than if cold air were used, and drafts within the stable would be less objectionable.

Wall construction that would permit vapor to pass out readily might be developed; for example, an inner wall of low vapor resistance, preferably insulated so that the inner surface would be above the dewpoint, an outer wall covering, and a space between the outer and inner wall ventilated to the outside at top and bottom to allow the vapor to escape. Unfortunately, such construction would be rather expensive, and it has other definite limitations. Obviously it would fail entirely if it were not possible to keep the inside wall surface above the dewpoint of the barn atmosphere.

On the basis of present knowledge, the most positive and least expensive method of preventing condensation within the walls would be the use of vapor-resistant barriers at or near the inner face of the wall. Vapor barriers will not, however, prevent condensation upon the indoor surface of a barn wall. The idea of vapor barriers in barn construction is not new. The application of the principle to different types of walls is not generally understood, however, and it may be advantageous to discuss this phase in some detail. Vapor barriers on the inner face of the lining would work particularly well with wall section 2B, since the inner wall temperature is above the dewpoint for the humidities and temperatures illustrated, and no condensation would occur on the inner face of the vapor barrier. The barrier might even be located on the face of the studs below the inner lining and still be above the dewpoint for humidities below 80 per cent. From the standpoint of thermal resistance the studs, however, are not as efficient as fill insulation and the calculated temperature gradients at the studs are indicated by dotted lines. Since the temperature of the inner face of the studs is lower than that of the inner face of the lining adjacent to the insulation, that surface becomes the governing factor. The use of insulation means less heat loss through the walls, and this in turn means that more heat is available to use for ventilation. In other words, for a given barn temperature more outside air can be used for ventilation to reduce humidity where the walls are insulated than where they are not.

Increasing the vapor resistance of the inner surface of wall 1A would probably have the effect of decreasing the transfusion through the sheathing and increasing the inner surface condensation. Condensation on the inner surface of the sheathing adds a decay hazard. A vapor barrier installed so that condensation is kept away from sheathing, studs, and siding reduces the hazard accordingly, though the dripping water may still be a nuisance. The same principle also applies to wall 1B. A barrier applied to the inner surface of 2A would protect the interior of the wall, though it might mean increasing the surface condensation at higher humidities. Condensation on the barrier at that point



TYPES OF WELL INSULATED CONCRETE WALLS

*U = (1" AIR SPACE FILLED WITH GRANULAR INSULATION) = 0.16 U = (1" AIR SPACE NOT FILLED) = 0.26

would be less objectionable than having it collect within the wall.

Complete elimination of condensation on windows is more or less impractical. It may be minimized by maintaining lower humidities and by using storm sash, but even these provisions will not entirely prevent condensation in extremely cold weather. Window frames and sills should be designed to drain rapidly to dispose of any condensation.

The Forest Products Laboratory has been making tests on the vapor resistance of various materials used in building construction and also on many materials that might be used for vapor barriers. Although these tests are still under way and have not covered all possible materials, enough information is available to permit the selection of a number of materials that are highly resistant to the passage of water vapor. Among these are (1) light-weight asphalt roll roofing material, (2) asphalt impregnated and surface-coated sheathing paper, glossy surfaced, weighing 35 to 50 lb per roll of 500 sq ft, (3) laminated paper made of two or more sheets of kraft paper cemented together with asphalt, 30-60-30 grade, (4) doublefaced reflective insulation mounted on paper. None of the materials listed are 100 per cent resistant to vapor transmission, but they are intended to reduce the amount entering the wall to the point where any that does enter can escape outward through the outer sheathing without further damage. Painting the inner lining with two or more coats of asphalt or aluminum paint will also be helpful, though these coatings are not as effective as the other barriers mentioned. Furthermore, paint coatings do not offer protection if there are numerous definite cracks or crevices in the surface of the inner sheathing. Such coatings would be more effective on plywood or similar sheet materials having few joints than on standard lumber sheathing.

Barriers as suggested for side walls should also be considered at the ceiling in barns having a hay mow over a stable.

The condensation problem is not limited to dairy barns, but may exist in any tight shelter housing animals or other types of farm buildings where some heat and moisture are present during cold weather. The principles of prevention and protection applied to cattle barns will also apply to other types of occupancy.

Discussion by G. B. Hanson

MEMBER A.S.A.E.

IN THE case of concrete construction, experience shows that under all ordinary conditions of humidity and temperature walls of this material are free from difficulties attributable to penetration of water vapor. In the case of a homogeneous material such as solid concrete or other solid masonry material, available evidence suggests that what small quantity of water vapor is able to penetrate into the wall flows on through, escaping from the cold side of the wall in vapor form. Doubtless this same natural resistance to flow of water vapor accounts for the fact that common types of insulated concrete construction have also given excellent service without an application of a vapor barrier.

The illustration (preceding page) shows the more usual types of insulated concrete walls used principally for dwellings and livestock structures. Experience shows that under normal conditions, even in dairy barns and air-conditioned homes, these walls need no vapor-proofing treatment. In cases of extreme exposure, where large differences in vapor pressure exist on the two sides of a wall, a vapor barrier may be applied as an additional precaution. There is no evidence, however, that walls of type 3 or 4 need a vapor-proofing treatment even under conditions of severe exposure.

Where it is desired to provide a vapor barrier for walls of type 1 or 2, however, the most practical treatment is a two-coat application of aluminum paint. Only aluminum paint of high quality should be used and it should be of the type recommended for outdoor exposure. To provide a smooth surface for painting, a neat cement grout may be rubbed into the wall surface before applying the aluminum paint.

Of the different vapor barriers reported by Teesdale thus far, the most practical for walls of type 5 or 6 is perhaps the application of an asphalt sheathing paper on top of the insulation board and under the metal lath which holds the plaster. It is important that this paper be an asphalt-impregnated and surface-coated sheathing paper, with glossy surface and weighing 35 to 50 lb per roll of 500 sq ft.

The refrigerated storage is a different type of farm structure which requires special protection of the insulation against water vapor. In this case the problem is approximately the reverse of the one found in dwellings or in livestock structures. With relatively warm humid air outside the storage during the critical period and with temperatures within the storage of about 30 F or lower, there is a tendency for water vapor to penetrate the wall until it reaches the colder insulation where it condenses. For this reason the vapor barrier in cold storages should be applied on the inside surface of the masonry wall before placing the insulation. General practice is to coat the masonry wall with hot asphalt, then set the units of rigid insulation in place against the mastic. Construction of this kind has long given thorough satisfaction in cold storage buildings.

Mr. Hanson is agricultural engineer of the Portland Cement Association, Chicago, Ill.

Discussion by J. F. Schaffhausen

OUR research laboratory concurs with the technical findings of the U. S. Forest Products Laboratory and of the Rock and Slag Wool Association. Consequently, application instruction sheets call for the application of a vapor seal paper in accordance with the method outlined here by Dr. Teesdale. In new construction, where paper-backed batts are used, the vapor seal paper is not recommended since the backing is considered adequate under normal conditions.

Our laboratory has directed its effort toward finding an adequate vapor barrier. This investigation covered most of the likely papers manufactured and considered the development of a new product to meet the need. Most of the material tested was immediately discarded because of high permeability. The papers that withstood the preliminary test were tested repeatedly to check the results obtained. The material used for testing represented regular stock material secured from dealers at various points, as well as samples from various runs submitted by manufacturers. The acceptable material was further subjected to tests on bursting strength (Mullen), and tear strength based on the standard test using the Elmendorf tear tester. After research reported its findings, it was necessary to consider the marketable price of the papers that suited the purpose, with the result that our organization decided to supply a material known as vapor-seal paper. This material falls within the allowable class based on the present requirement, namely, the tentative one set up by the Forest Products Laboratory.

Mr. Schaffhausen is agricultural engineer of Johns-Manville Corporation.

Before we can analyze conditions with a view toward satisfactory control of condensation in the dairy barn, we should sum up and define what the dairy barn is and what it is meant to do and we should keep these factors in mind while considering improvements.

From our investigation, we would say that a dairy barn is a building for housing milking cows, designed in such a manner that the animals housed therein produce the maximum amount of milk at the lowest possible expense. Authorities differ on these requirements, but they do agree generally that the temperature should be maintained between 45 and 50 F and the average humidity at approximately 60 per cent. Further, air should be circulated so that there will be a complete change within the structure approximately six times per hour, giving each cow the benefit of the oxygen in approximately 3542 cu ft of air each hour. Research to date has been directed toward developing the outlined conditions as well as reducing chore time and developing feeding methods. The result of this research is reflected in new records in production and better net income.

Consequently, in seeking to develop a barn that has structural improvements over the existing types, it becomes necessary to first consider maintaining the present status quo. If we increase the overall cost per head, we must justify the additional cost by either lowering depreciation of the structure or increasing production.

Taking these conditions into consideration and realizing the detrimental effects of excess moisture in barns, it becomes necessary to control the humidity by maintaining it at the lowest possible percentage dictated by the requirements of maximum production. To accomplish only this is a simple task for the engineer or architect, since it is simply necessary to circulate sufficient dry air through the building to remove excess moisture. However, this method would require preheating of the air before it is discharged into the structure, so that necessary temperature levels could be maintained. Preheating would also reduce the volume of air necessary, thus tending to prevent drafts.

Another alternative that we may follow is to insulate adequately both side walls and ceilings of the structure to conserve body heat and circulate only enough fresh air to produce the desired conditions.

In this way we can eliminate the formation of condensation on interior walls and ceilings, and we can also prevent the passage of water vapor through the wall areas by applying a moisture barrier as explained by Dr. Teesdale in his discussion. But no vapor barriers are 100 per cent effective. Consequently, the venting of all insulated areas has been found to be an advantageous precaution since this allows air to circulate freely, removing any moisture that may pass through the vapor barrier. As a further precaution, it is well to consider materials for construction that are not affected by moisture.

But all of these precautions are usually of little value in actual field practice, for frequently it is found that a building is properly engineered to meet given conditions for, let us say, a 40-cow herd, and through no fault of the engineer or companies furnishing the materials out of which the structure is built, the farmer decides to house 30 or 35 cows instead of the intended 40; or, in some cases, he may put in more cows. These factors upset all calculations, and the next thing we know a complaint is registered or at least aired around at farm meetings about the beads of water that are forming on side walls and ceilings during cold weather. Further, in some isolated cases, the decay caused by such neglect, or shall we call it the human factor, is noticed by outsiders and the engineer is condemned immediately without considering the factors outlined.

Before we can plan closer control over condensation, it is the task of this body to educate the farmer to expect no magic either from building materials or engineering. He can expect a reasonable return on his investment only when he properly engineers his buildings and uses them to accommodate the exact number of animals for which they are planned.

Discussion by D. D. Grassick

IT IS well known that heat transfer from a warm to a colder area is accomplished by conduction, convection, and radiation. Radiation was formerly given but little consideration, and while air spaces were employed along with mass type insulating materials to reduce the rate of heat transfer through building walls or roofs, main attention was paid to reducing conduction by the use of porous bulk materials. Heat transfer by conduction takes place through the molecular construction of either solids or gases. Heat transfer by convection and radiation, however, takes place only in air spaces, either large or minute. Convection heat transfer involves the absorption of heat by the air adjacent to a warm surface, causing it to rise as expanded, eventually spreading to a colder surface which in turn absorbs heat from the air, contracting it and causing it to move downward. Thus a sort of continuous conveyor operating between the opposing surfaces of the air space is established, and governed in its movement by the size and position of the space and the temperature difference between the opposing surfaces.

Heat transfer by radiation takes place independent of the air movement, and, for all practical purposes, independent of the width of the space. It is in the nature of long wave length electromagnetic energy in the infrared range, projected from the warm surface and becoming active heat only as absorbed by the first opaque barrier in its path. The absorption of this energy stimulates molecular activity generating heat in the substance by which it is absorbed.

Radiation, therefore, takes place only in an air space, and the proportion of radiant heat to the total heat transfer across the space is governed by the type of surfaces bounding the space, the temperature differences, and the position of the space. The U. S. Bureau of Standards and other authorities have determined that across an ordinary air space with substantially nonreflective surfaces from 50 to 80 per cent of the total heat transfer may be radiation. Each type and color of surface has a specific ability to emit, or reflect radiant heat energy. The theoretical dull black surface will absorb 100 per cent of the radiation impinged upon it, reflecting none. It will also emit or project radiant heat at a rate of 100 per cent. Most ordinary building materials such as lumber, brick, waterproofing felts, etc., will emit and absorb radiant heat at a rate of 90 to 95 per cent, and reflect only 5 to 10 per cent back toward its source. Bright metallic surfaces, however, are in general high reflectors and low emitters of radiant heat energy. Polished aluminum reflects 95 per cent of the radiant heat energy impinged upon it, and will emit or project it at a rate of 5 per cent, or one-twentieth that of a dull black surface. This action is much like a mirror reflecting light, but the difference lies in the fact that it functions in light or darkness as the wave length of radiant heat energy is beyond the range of visible light, and as above stated is in the infrared range, operative in complete darkness.

As aluminum has the ability to retain these surface effects and can be rolled to extremely thin sheets called foil, practical utilization of the high reflective and low emissive qualities has been made possible for insulative purposes.

Mr. Grassick is district supervisor of Alfol Insulation Co.

Aluminum foil of 99.5 per cent minimum purity and from 0.00035 to 0.00045 inch in thickness is commercially available for building insulation purposes. As the functioning is entirely in the surfaces, this thinness is desirable for economic and light weight purposes.

Several forms of application have been devised retaining the basic principles, ranging from plain sheets of foil to foil mounted on one or both sides of heavy building papers, to foil bonded to rigid insulating boards, plaster boards, or pliable blanket insulating materials.

In each case, however, the material is so placed that either one or both of its foil surfaces are exposed to an air space, nominally ¾ in or more in width. So used, 95 per cent of the radiant heat established by the air space is "screened out" or directed back toward its source. In a single air space bounded on one side by the foil surface it is immaterial whether the foil is on the warm or the cold side of the space, as the same overall result would be accomplished—by low emission if on the warm side and by high reflection if on the cold side.

Research has established that in building walls a single air space faced on one side with aluminum foil will develop insulative efficiency equivalent to ¾ in of average mass type insulating material having a K factor of 0.30 Btu's per inch per square foot. This overall insulative effect is made up of the combined resistance of the air in the space, the surface films of still air and the virtual elimination of the radiant heat factor by the foil surface. Thus, by the use of a single or multiple foil surfaces and air spaces, practically any degree of desired insulative effect can be accomplished, limited only by available space.

The foil, being all metallic, is of course waterproof and substantially vapor proof. In the combined form with waterproofed duplex paper backing or core, any minute pinholes which might occur in the plain thin foil are sealed against vapor movement.

Aluminum foil insulation is ordinarily placed in spaced position between the studs, joists, or rafters, being attached lengthwise to the face or sides of the framing. When plain foil is used, it is covered on the inside with duplex waterproofing paper over the framing, and in the paper-backed types the foil faces the outside while the paper faces inside. Where employed in locations other than unused residential attics and the like, structural coverings of lumber, plywood, plaster, etc., are recommended for the inner wall finish.

Used in this way vapor barriers are established by both the foil and the paper, and the hazard of condensation materially reduced. This construction permits an air space also immediately behind the outer structural wall, serving as a venting medium or breathing space. The physical laws of vapor movement with pressure differences, and its conversion to condensate or frost under certain atmospheric and relative humidity conditions, are known and have been extremely well illustrated by Dr. Teesdale in his paper.

Our research permits us to subscribe wholly to the principles he sets forth, and our recommended applications all stress the provision of barriers to vapor movement on the side of the structure where highest humidity and temperature will prevail under condensing conditions, as well as the provision of a venting or breathing space on the cold side of the structure under the same conditions.

In the use of aluminum foil reflective insulation a few different conditions develop, having a bearing on condensation and noteworthy at this time. The temperature gradient curve through the insulated wall when bulk type insulation is used, is substantially a straight line running downward diagonally across the wall from the high inside to the low outside temperature points. When foil is used in single or multiple layers or partitions, the temperature gradient curve from the warm to the cold side is more in the nature of a series of slight curves or half loops, until the last outer air space is reached, when a severe drop in the curve develops between the last foil surface and the inner face of the outer wall. The foil being extremely light in weight and low in specific heat, quickly assumes a fairly high temperature within itself through contact with the air on the warm side and the small amount of radiant heat it absorbs. Its low emissive quality dams up this heat, and some of the temperature measurements in our research have shown the foil actually somewhat higher in temperature than the air at the center of the air space between it and the warmer surface. With this condition a sudden drop in outside temperature has a minimum effect on the temperature of the inner foil layers. This gradual step-down in temperature from the warm to the cold side of the insulated wall causes internal conditions whereby a higher relative humidity or a much more severe drop in outside temperature is necessary to have condensation occur than would be required otherwise.

Another point in the use of foil is the fact that it tends to accelerate the rate of rise in the temperature of the inside wall covering when a heat source is supplied within the room or building. Heat passing through the wall covering, whether wood, plaster, fiberboard, etc., into the first air space behind it, heats the air in the space much faster than it would any equivalent volume of bulk material, and most of the radiant portion of the heat crossing the air space is directed back toward its source by the foil. This in effect causes the wall covering material to be heated up from both sides, minimizing the hazard of condensation forming on the inner wall surfaces which sometimes occurs when the cold inner wall is exposed to high humidity.

Power Equipment for Injecting Carbon Bisulfide into Soil

(Continued from page 352)

of at least the upper 8 in of the soil should be sufficient to germinate seeds, the subsoil should preferably be dry. After preparation of the land, the complete equipment as shown in Fig. 3 is required for effective application of the carbon bisulfide. A V-block ridger is attached immediately behind the chisel standards to drag a small ridge of soil up over the area disturbed by the chisels (Fig. 4). A heavy water-filled roller follows behind the ridger and presses down the ridges, thus sealing the surface which confines the CS_2 vapors in the soil. The depth of application of CS_2 varies with the soil and also with the disease or weed being treated, but in general injection from 6 to 10 in depth gives satisfactory control.

Application of CS_2 with the power applicator is of course much faster than with hand injectors. However, use of power equipment is generally limited to areas requiring ten drums or more of CS_2. Smaller quantities are more economically applied by hand. Approximately six 50-gal drums are used per acre. With the power applicator, treatment can be made at the rate of approximately one-half acre per hour. The power required to operate the applicator is not great since treatments can only be made where the soil is in good condition. A 15 or 20-hp tractor will adequately handle the equipment. The metering pumps are giving consistent results throughout a considerable speed range, but the best speed seems to be from 2 to 2½ miles per hour. Since carbon bisulfide is relatively expensive and its use generally limited to small areas, it is to be expected that power applicators will be operated only by commercial companies or contractors.

Soil Moisture Control by Irrigation

By R. A. Work

ASSOCIATE A.S.A.E.

IN 1930, in response to requests from the pear growers of the Rogue River valley in southern Oregon, the U. S. Bureau of Agricultural Engineering in cooperation with the Oregon Agricultural Experiment Station initiated experiments to determine when and in what amounts water should be applied for the maximum production of pears of good storage and dessert quality. In 1932 the U. S. Bureau of Plant Industry joined these agencies, and the Medford branch of the Oregon station was established. The experiments have been cooperatively conducted there since that date.

The soil at the Medford station is Meyer clay adobe, a clay of pronounced adobe structure, from four to six feet deep. The soil structure and texture appear to be quite uniform at all depths below the first foot down to the horizon of disintegrated material just above the parent rock, which is shale. The soil is typical of about fifty per cent of the pear orchard soils in the Medford area. The pear trees at the Medford station were fifteen years old in 1932. The average rainfall is 18.08 in, only a small part of which occurs during the growing season.

In this work the available water-holding capacity of the soil was expressed as a range of 100 per cent, zero availability in this soil being at a moisture content of about 16 to 18 per cent (wilting percentage) and 100 per cent availability being about 30 to 34 per cent (field capacity). In our experiments soil-moisture differences were confined to the available range.

Early experimenters in soil moisture concluded that the "optimum soil moisture content" extended from about 25 to 90 per cent of the available capacity. More recently Veihmeyer and Hendrickson[14]* have defined "readily available moisture" as the entire range of soil moisture between field capacity and approximately the permanent wilting percentage, thereby extending the "optimum range" to include the entire available range.

DECREASED PRODUCTION NOTED BEFORE WILTING PERCENTAGE IS REACHED

In the work at Medford, wilting percentages were determined by growing potted sunflower plants[17] by methods similar to those used by Veihmeyer and Hendrickson, and Taylor and associates. The Medford wilting percentages are probably somewhat higher than Taylor's "ultimate wilting point" and probably coincide more closely with those of Veihmeyer and Hendrickson's "permanent wilting percentage".

It became apparent soon after the experiments were initiated at Medford that pear trees definitely suffered for lack of water long before soil moisture in any portion of the root zone, as nearly as could be determined by the usual soil sampling technique, approached the wilting percentage. Lewis, Work, and Aldrich[9] concluded that "the rate of growth of pear fruits is markedly affected by comparatively small variations in the moisture content of the soil of the root zone, even when the moisture content is well above the wilting point". Fig. 1 shows that in 1932 at the Medford station the rate of growth of Anjou pears was decreased from "normal" by as much as 50 per cent by allowing soil moisture to be reduced to 15 per cent of the available capacity, and that when moisture content fell below 70 per cent of the available capacity, the rate of growth of the fruit was generally reduced. Naturally when rate of fruit growth is reduced for a period of time, the ultimate size at harvest is correspondingly reduced and less boxes per acre will be harvested. Later results at Medford substantiate completely those obtained during the early years of the work.

RESULTS SUBSTANTIATED IN OTHER SOILS

Some workers in referring to the Medford work infer that the conclusions of our Oregon group differ from those of workers in the soil moisture field elsewhere, because we have worked with an unusually heavy clay soil. This may be true, and it is unquestionably true that the Medford results have differed outstandingly from results of some other workers in the soil moisture field.

At the same time, still other workers—Bartholomew[3], Furr and Degman[4], Furr and Magness[5], and Taylor and Furr[11], to mention only a few—have concluded that different varieties of fruit trees suffered for lack of soil moisture before soil moisture reached the wilting percentage. We are inclined to believe that plants in most soils suffer in greater or lesser degree for lack of soil moisture before soil moisture in any portion of the root zone approaches the wilting percentage. In the case of the Medford soils, the results were so clear cut that the point could be readily proved. In the case of other and lighter soils with more complete root distribution and probably with more rapid movement of soil moisture from moist soil masses to extracting roots, the responses of trees to differences in soil moisture within the available range have either not been as clear cut or have been so slight as to be regarded as within the range of experimental error.

Magness[10] stated: "On moderate to light and well-drained soils, root distribution in the soil is generally much more perfect and soil particles on the average are closer to feeder roots. Also, the capillary movement of moisture in such soils, according to McLaughlin's results, is likely to be more rapid than in very heavy soils. Under these conditions the soil will supply moisture to the roots at near the required rate for optimum functioning of the tree so long as moisture supply is measurably above the wilting percentage. With very heavy soils, on the other hand, with a less perfect root distribution, and with slower capillary movement through the soil, the rate of water supply to the roots is apparently reduced when the soil mass as a whole has a large amount of available water still present. It seems probable that the soil in immediate contact with roots under these conditions may be relatively much drier than that even a short distance away which supplies water only by capillarity. Soil samples at the best can only represent an average of the moisture condition in a considerable mass of soil. We need much more evidence on the rate of capillary movement of moisture in soils of different texture. It

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*Superscript figures refer to literature cited at the end of Mr. Work's paper.

seems probable that the rate that water is supplied to roots by the soil depends in considerable part upon the rate of this capillary movement. Thus a heavy soil will apparently supply water more slowly but for a long period, while a light soil may supply water much more rapidly with the available supply being rather quickly used up by the trees."

Lewis[7] has recently shown that capillary water is not transmitted as readily through fine as through coarse-textured soils. He has also shown that as soil moisture declines a steeper moisture gradient is required to move moisture at the same rate, or the capillary moisture moves more slowly toward the drier zone with the same moisture gradient. He suggests that soil moisture at the midpoint between absorbing roots might still be well above the wilting percentage when its rate of movement towards roots became so slow as to limit tree responses.

It seems clear to us that varying plant responses to different soil moisture contents within the available range can be explained by differences in soil type, root distribution, root-top ratio, and evaporating power of the air. To say that soil moisture throughout the available range is equally available to plants, does not seem to be in accord with the extensive evidence to the contrary.

But, returning to the Medford experiments, over a period of five years fruit production on the frequently irrigated plots has consistently exceeded that in other plots. Very little commercial difference in fruit quality has been noted in the different plots, and no harmful effects to the trees have been observed on the heavily irrigated plots.

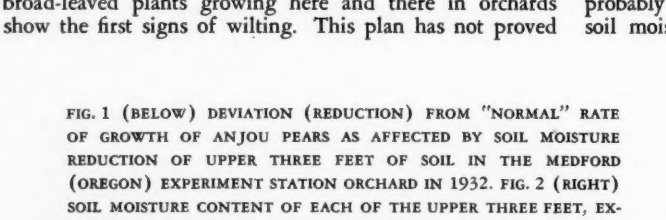
After the experiments had progressed for some time and clear-cut results were obtained, it became evident that methods of applying the experimental results to commercial orchards should be developed.

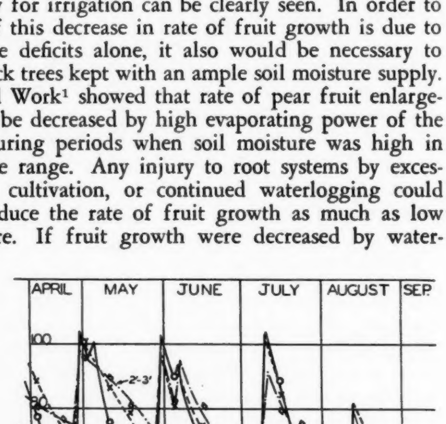
In certain locations in California where the cost of irrigation water can be met only by the maximum production of especially profitable crops, commercial soil-moisture laboratories in return for an annual fee keep the growers advised as to soil-moisture conditions in their orchards and as to when and in what amounts irrigation water should be applied. A minimum use of water consistent with efficient production is advised. Veihmeyer and Hendrickson have generally recommended[14] that irrigation water be applied to orchards at about the wilting percentage, or whenever broad-leaved plants growing here and there in orchards show the first signs of wilting. This plan has not proved satisfactory with pear orchards on heavy clay soils because the trees suffer very seriously for lack of water for days or even weeks before the weeds show any signs of wilting.

Veihmeyer and Hendrickson recently (1938) appear to have concluded that the use of broad-leaved indicator plants is not always the most suitable method, for they say[15]: "The chief difficulty in using the response of deciduous trees or indicator plants is the suddenness with which wilting occurs. Ordinarily the first signs of wilting, as indicated by a drooping of the leaves, decreased rate of growth of fruit, or other plant responses, occur only a few days before the readily available water is exhausted. If the grower waits for the plants or trees to show visible signs of wilting before preparing for irrigation, the last trees to be irrigated, especially if the area to be watered is large and the irrigating stream is small, sometimes suffer from the lack of water. Regular soil sampling generally gives the grower a much longer period in which to prepare for irrigation, because he can predict with a reasonable degree of accuracy when irrigation will be necessary."

Some investigators have suggested that irrigation dates can be determined by measurements of rate of growth of fruit[12]. This method seems to work satisfactorily with lemons, because lemons when supplied with ample moisture grow at an approximately uniform rate and apparently increase their rate of growth sufficiently after irrigation to make up for the decreased rate of growth caused by soil moisture shortage during a short period before irrigation. Pears, however, do not react this way, at least certainly not as markedly as lemons. Decreased growth of pear fruit caused by soil moisture shortages *cannot be recovered after an irrigation is applied*. If one is to gauge the time of irrigation by rate of fruit growth, the trees must suffer for a period of time, thereby showing a slower rate of fruit enlargement, before the necessity for irrigation can be clearly seen. In order to determine if this decrease in rate of fruit growth is due to soil moisture deficits alone, it also would be necessary to provide check trees kept with an ample soil moisture supply. Aldrich and Work[1] showed that rate of pear fruit enlargement could be decreased by high evaporating power of the air, even during periods when soil moisture was high in the available range. Any injury to root systems by excessively deep cultivation, or continued waterlogging could probably reduce the rate of fruit growth as much as low soil moisture. If fruit growth were decreased by water-

FIG. 1 (BELOW) DEVIATION (REDUCTION) FROM "NORMAL" RATE OF GROWTH OF ANJOU PEARS AS AFFECTED BY SOIL MOISTURE REDUCTION OF UPPER THREE FEET OF SOIL IN THE MEDFORD (OREGON) EXPERIMENT STATION ORCHARD IN 1932. FIG. 2 (RIGHT) SOIL MOISTURE CONTENT OF EACH OF THE UPPER THREE FEET, EXPRESSED AS PER CENT OF THE AVAILABLE CAPACITY, IN A COMMERCIAL PEAR ORCHARD NEAR MEDFORD, OREGON, IN 1936





logging of the soil, further addition of water would doubtless aggravate the condition. In such cases, soil moisture determinations would be essential if the decreased fruit growth were not to be interpreted in an incorrect manner. Rate of fruit enlargement and tree suffering are not always directly correlated with soil moisture content.

It has also been suggested that need for irrigation can be determined by the appearance of the trees, or of the soil. As soil moisture becomes depleted, the foliage of pear trees usually turns a darker green, but the color difference between well-irrigated and poorly irrigated trees is clearly apparent only if such trees are side by side. Judging the need for irrigation by appearance of the soil is a difficult matter with heavy clay soils, which retain much moisture at the wilting percentage. After several years experience with this particular soil, during which time many thousand soil moisture determinations have been completed, the author must confess that he can only with difficulty estimate soil moisture content within 20 or 25 per cent of the actual available percentage.

It has also been suggested that pear orchards in the Rogue River valley, if irrigated approximately every thirty days, will produce maximum crops and the expense of determining soil moisture might be avoided. Our experience, as reported later in this paper, makes us think this suggestion impractical.

MOISTURE DETERMINATION AS A GUIDE TO IRRIGATION

It appears to us, after several years' work, that actual determinations of the moisture content of the soil itself must be carried on if the most efficient use of soil, water, and trees is to be made.

Actual determination of soil moisture in the major part of the root zone (the upper three feet with pears on heavy clay soil[2]) affords at least four specific and necessary indications for the conduct of orchard irrigation. First, it indicates exactly how much soil moisture is available for use by the trees. Second, by periodic sampling at intervals of say a week to ten days, the orchardist knows how rapidly soil moisture is being lost and can anticipate very closely the time when soil moisture will be seriously depleted. Third, by taking samples after irrigation, the orchardist may learn to what depth and in what amount irrigation water penetrated and has a measure of the efficiency of his irrigation methods. Fourth, knowing his soil moisture condition and the rate at which moisture is being lost, the orchardist can more intelligently coordinate other orchard operations, such as spraying, blight control, harvest, etc., with irrigation, and is in a much better position to judge whether irrigation, or some other equally important orchard operation, should have the right of way.

To determine if detailed soil moisture sampling in commercial orchards could be put on a sound practical basis, a soil moisture control project was initiated in 1936 in the vicinity of Medford. During the early spring, determinations of field capacity and permanent wilting percentage were completed for each of twenty-one orchard blocks. Beginning early in March and continuing at weekly or ten-day intervals, samples of soil moisture were taken at one-foot increments to a depth of three feet at about five locations in each orchard. About two days later reports of the moisture contents in terms of availability were mailed or telephoned to each of the cooperating orchardists.

In 1937 thirty orchard blocks were included in the program. In 1938 the program was concluded, and by the end of that year soil moisture histories had been obtained on thirty-eight separate commercial orchard blocks, representing ten soil types and a wide range of soil depths, topography, size of trees, orchard management, etc. Since some blocks were included for two or three years, the total number of blocks serviced for one season over the three-year period equalled sixty-four.

The orchards included in the project were on soils similar to Meyer clay adobe, and on the basis of the results secured on that soil at the experiment station we recommended that water be applied when the average soil moisture of the upper three feet (containing approximately 90 per cent of the tree roots) had decreased to about 50 per cent of the available capacity.

The recommendation to maintain soil moisture in heavy clay soils above 50 per cent of the available capacity was arbitrary, as there are undoubtedly times when evaporating power of the air is low that soil moisture may be allowed to go below 50 per cent of the available capacity without visible reduction in plant responses, just as during extremely warm weather pear trees may suffer as evidenced by decreased rate of fruit growth before soil moisture declines to 50 per cent of the available capacity. However, we believed from our soil moisture studies [1, 2, 8, 9], that if soil moisture were maintained at or above 50 per cent of the available capacity, extremely frequent irrigation would not be required, nor would pear trees suffer materially during periods of high evaporating power of the air.

SOIL MOISTURE RECORDS SHOW INFLUENCE OF VARIOUS IRRIGATION PRACTICES

Soil moisture records for each orchard were plotted each year in the manner illustrated in Fig. 2. From studies of the sixty-four soil moisture charts certain conclusions were drawn.

In *1936* two to five irrigations were applied to twenty-one blocks. The irrigation recommendations were closely followed in thirteen blocks, and in these the interval between irrigations ranged from thirty to fifty-nine days. In one orchard having fairly shallow soil the first irrigation began April 28. In another, the first irrigation was not applied until July 8, or seventy-two days later, yet in both cases, the first irrigation was applied at approximately the correct time to prevent tree suffering.

In *1937* one to four irrigations were applied to thirty blocks. The irrigation recommendations were closely followed in ten blocks and in these the interval between irrigations ranged from 21 to 48 days. In one of the ten blocks the first irrigation began May 15, while in another the first irrigation was not applied until sixty-eight days later. The first irrigation in both orchards was applied at approximately the correct time according to the soil moisture studies.

In *1938* two to five irrigations were applied to thirteen blocks. The irrigation recommendations were closely followed in only five blocks, and in these the interval between irrigations ranged from 21 to 36 days, not as wide a range as in previous years. Similarly, the difference between dates of first irrigation was not as great as in either 1936 or 1937, ranging only between May 23 and June 6. In the other orchards in which irrigations for some reason could not be, or were not, regulated according to soil moisture, date of first irrigation varied more widely—from May 26 to June 21.

During the three-year period, of sixty-four orchard blocks studied, on twenty-eight, irrigations were closely timed in accord with soil moisture conditions. In these 28 blocks the time interval between irrigations ranged from 21 to 59 days. Date of first irrigation ranged from April 28 to July 23, a difference of nearly three months. In one orchard, in which irrigation was closely regulated according to the soil moisture samples, the date of first irrigation in 1936 occurred on April 27, but in 1937 not until July 3, or more than two months later. Elapsed time between irri-

gations in this orchard varied from 19 to 37 days during the three-year period. In another orchard, with closely regulated soil moisture, the first irrigation of 1937 was applied on July 19, but in 1938 the first watering started 45 days earlier, on June 4.

These results show clearly that the maintenance of soil moisture within the upper half of the available range (shown to be necessary for satisfactory pear production on the heavy soil of the Medford branch station) requires very different irrigation schedules on different orchards. The data indicate that because of wide differences in soil depth, soil type, tree size and vigor, and because of wide variations in evaporating power of the air from month to month and also from year to year, it is quite impracticable to adopt any uniform irrigation program either as to date of application of first or last irrigation, interval between irrigations, or number of irrigations.

It may be significant that of the sixty-four orchard blocks studied, the average soil moisture in the dryest foot level was allowed to reach the permanent wilting percentage in five cases only; as low as 20 per cent of the available capacity in 16 cases; and was maintained above 50 per cent of the available capacity almost continuously in 33 cases. In those cases where soil moisture was not maintained above the 50 per cent minimum, failure to do so was attributed to one of three principal reasons, namely, (1) inability of the grower to secure water on demand when needed, (2) conflict with other important orchard operations, such as spraying, blight cutting, etc., and (3) failure to pay attention to soil moisture information as furnished.

The failures to properly maintain soil moisture did not disprove the value of the information the growers had, but rather emphasized the need for such information, as only thereby can such difficulties be met. The fact that more than one-half of the 64 blocks maintained soil moisture at nearly all times above the 50 per cent minimum offers fair proof that the maintenance of highly available moisture in commercial pear orchards on clay soil is entirely practical.

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Notes on Industrial Use of Farm Products

Senate Document No. 65, entitled "Regional Research Laboratories" has just been issued by the Government Printing Office. The bulletin consists of a four hundred-page study by the Department of Agriculture on "Chemurgic Research Opportunities." Copies are probably available through United States senators and representatives.

* * *

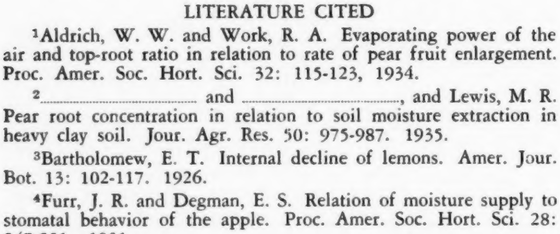
The Glidden Company, manufacturer of soybean oil paints, will spend $346,000 to build a 2,000,000-bu soybean elevator in Chicago.

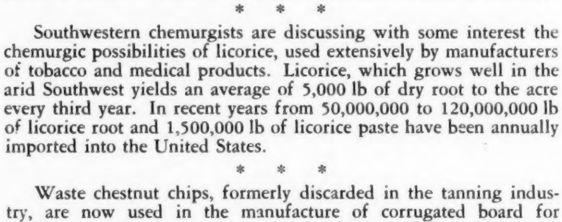
* * *

Southwestern chemurgists are discussing with some interest the chemurgic possibilities of licorice, used extensively by manufacturers of tobacco and medical products. Licorice, which grows well in the arid Southwest yields an average of 5,000 lb of dry root to the acre every third year. In recent years from 50,000,000 to 120,000,000 lb of licorice root and 1,500,000 lb of licorice paste have been annually imported into the United States.

* * *

Waste chestnut chips, formerly discarded in the tanning industry, are now used in the manufacture of corrugated board for shipping containers. *From National Farm Chemurgic Council.*





MECHANIZED FORAGE HARVESTING

Bert Knapp, dairy farmer of Monroe, Mich., has developed a system of harvesting forage with mechanical equipment and a minimum of hand labor, using the field chopper and special hauling wagon shown above. The wagon is a spreader rebuilt to provide suitable hauling capacity and unloading direct onto the feed table of the blower used to fill silos and hay mows. An electric motor running the spreader apron accomplishes the unloading without hand pitching or dumping. Shocked corn is fed to the field chopper by hand

NEWS

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

WAR PREPAREDNESS

THERE has been appointed recently a War Resources Board of six members, of which Dr. Karl T. Compton may be said to be the representative of science and engineering. Since this appointment, the Board has been working continuously, reviewing the Army and Navy preparedness plans.

Experience from the Council of National Defense, headed by Walter S. Gifford, President of the American Telephone and Telegraph Company, in 1917, is available to the new Board through his membership. It is assumed that the War Industries' Board, now an advisory arm of the Army and Navy Munitions Board, in the event of war would become a War Resources Administration, reporting directly to the President. Presumably, it would attempt to coordinate the economy of the country with particular attention to the munitions requirements of the Army services and should war come, it would be assumed that these requirements for munitions would be coordinated with the needs of the civilian population.

Information at the office of the War Resources Board indicates that should a war-time industrial mobilization be necessary, it would revolve around the War Resources Administration, but that the actual administration of various activities would be in the hands of the regular agencies handling them or with new agencies.

One effective instrumentality developed in the twenty-two years that have passed since the last war are the trade and technical associations. Practically all the industries are highly organized and are in possession of statistical and other information which can be quickly put at the disposition of a War Resources Administration. In this connection, the Annual Meeting of the Army Ordnance Association is to be held October 11 and 12. On October 11th, there is to be an industrial preparedness luncheon. In the afternoon there will be a round table discussion of preparedness problems conducted by General T. C. Harris, Assistant Chief of Ordnance. Benedict Crowell, President of the Army Ordnance Association, will preside at the dinner and General George C. Marshall, the Chief of Staff, will be the dinner speaker.

Fall Meeting Plans Under Way

PLANS for the fall meeting of technical divisions of the A.S.A.E. in Chicago, December 4 to 8, have progressed to the extent that Monday, December 4, has been set aside for committee and other special group meetings. The Power and Machinery and Farm Structures Divisions will hold concurrent meetings December 5 and 6, and the Rural Electric and Soil and Water Conservation Divisions on December 7 and 8.

The meeting will be held at the Stevens. Programs are in process of development by the Division Executive Committees.

Farm Equipment Institute to Meet at French Lick

FARM Equipment Institute will hold its 46th annual convention October 2 to 4 at French Lick, Indiana. Program features scheduled include the President's Address, by Charles T. Ray; "The Institute Year," by W. L. Clark, chairman of the Executive Committee; "The Business Scene Today and Tomorrow," by R. E. Desverninc; "The Cotton Problem and Its Relation to the Farm Equipment Industry," by Oscar Johnston; "Partners in Business," by Alfred W. Bernien; "Can We Do a Better Job of Merchandising," by Horace P. Howell; "The State of the Industry," by H. G. Davis; and addresses by H. C. Merritt, and by Merle Thorpe.

Entertainment is planned for the afternoon and evening programs.

S.A.E. Tractor Meeting in Milwaukee

ANNOUNCING the 1939 National Tractor Meeting of the Society of Automotive Engineers, Milwaukee, Sept. 28-29, John A. C. Warner, secretary and general manager of the Society declared that reduction of engine wear is the principal aim of the papers to be presented.

Air cleaners, oil filters, and surface finish are among the factors influencing engine wear to get attention at this two-day meeting. Sessions will be held at Milwaukee's Hotel Schroeder, as will the Tractor Banquet which climaxes the event. Plant visits also are being planned.

The program is under the direction of the SAE Tractor & Industrial Power Equipment Activity Committee headed by SAE Vice-President J. S. Erskine, International Harvester Company. The Milwaukee Section of the Society, chairmaned by Walter F. Strehlow, Allis-Chalmers Mfg. Co., is cooperating.

Personals

Deane G. Carter and *W. C. Hulburt* are two of the authors of Arkansas Agricultural Experiment Station Bulletin No. 380, entitled, "Influence of Rainfall, Cropping, and Cultural Methods on Soil and Water Losses."

C. L. Hamilton is author of "Terrace Outlets and Farm Drainageways," published as U.S.D.A. Farmers Bulletin No. 1814.

C. N. Turner, in Cornell Extension Bulletin 410, tells largely in pictures the story of "How Electricity is Used on the Farm."

ASAE Meetings Calendar

September 12-14, 1939—North Atlantic Section, Farmingdale, Long Island, New York.

December 4-8—Fall meeting, technical divisions, The Stevens, Chicago, Ill.

Storage Methods for Grain Sorghums

THE Summary of a report on the research study, "Storage Methods for Grain Sorghums," in the College of Agriculture, University of Georgia, gives the following information applicable to that area: "Stalk storage in the open was unsuccessful. Sorghum heads, at a moisture of 9 to 12 per cent, stored in the experimental cribs used in the study, kept satisfactorily and gave grain of good quality. Threshed grain must be dried to a moisture of 15 per cent or less before final storage is attempted.

Grain sorghum seed is susceptible to weevil damage, and this factor cannot be remedied by storing in tightly sealed containers. The grain may be dried artificially by forcing either heated or unheated air through the seed. Rapid drying adversely affects germination.

"A good stand is desirable both from the standpoint of yield and the production of small or medium sized heads. A plant spacing in the row of 4 in seems satisfactory. Germination properties of the seed should be determined before seeding, as sorghum seed varies widely in germination properties. Seeding should be done so as to bring the maturity date at or near the time of the first frost. Feeding of the grain in the late fall and early winter months simplifies the storage problem and is practiced by farmers in the vicinity of Athens."

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the August issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Clyde L. Anderson, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 301, Safford, Ariz.

S. J. Marek, 617 W. Alamo, Brenham, Tex.

Harris R. McDonald, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 394, Safford, Ariz.

Fred D. O'Berg, district engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Alexander, N. D.

David B. Poor, junior salesman, Massey-Harris Co. (Mail) 1827 1st Ave., S.E., Cedar Rapids, Iowa.

John E. Povelones, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 1902 Center St., Moundsville, W. Va.

George A. Randel, student, Sherman-Ferguson Mfg. Corporation School, Dearborn, Mich. (Mail) Dearborn Hotel.

Jeff G. Ray, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 253, Perryton, Tex.

H. P. Richter, buyer, Montgomery Ward & Co. (Mail) 2307 Park Place, Evanston, Ill.

H. H. Wilson, technical engineer, Imperial Oil Limited, Regina, Sask., Canada.

Modern tractor and implement designs, minimizing deadweight to lower operating costs, depend upon the improved properties of modern Nickel alloy steels to safely handle peak loads. Nickel—the fundamental alloying element—helps each ounce, each inch of metal carry greater loads. Nickel steels withstand fatigue, resist stress and shock. This avoidance of breakage safeguards owner satisfaction — creates owner enthusiasm by lowering cost-per-year.

Pulling four 16-inch bottoms through heavy soil in fourth gear takes brute power and the tractors—pictured below, take this gruelling service in stride. Tractor builders assure uninterrupted operation by specifying Nickel alloy steels for such parts as transmissions, drive shafts and other vital parts. Cast engine parts are often made from close-grained Nickel cast irons. To guard your equipment against peak load breakage, make certain all vital units are fortified with Nickel. Consultation on your problems involving the use of Nickel is invited.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

DIESEL TRACTOR ENGINES, *A. C. Jacquot.* Washington Sta. Pop. Bul. 156 (1939), pp. 28, figs. 13. This is a largely non-technical description of the four-stroke-cycle Diesel engine, the types taken up being, respectively, that which is turned over and preheated by an auxiliary small two-cylinder gasoline engine, that provided with a burner-heated coil in the cooling water circuit and started by an electric starting motor, and the type provided with built-in auxiliary combustion chambers and spark plugs for initial rotation and heating by gasoline operation. The two-stroke-cycle Diesel is also mentioned but is not here dealt with because of the limitation of its use to 5,000 hp and larger power plants. Comparison of the Diesel cycle with the Otto cycle of the ordinary gasoline engine is made by means of parallel columns of diagrams, a valve-timing diagram for the Diesel engine is included, temperature-pressure relationships during Diesel and Otto cycles are shown, and other features of design and operation are also illustrated. The oil-burning engine similar to the Diesel except in using spark ignition with lower compression (the so-called semi-Diesel) is very briefly noted.

In conclusion it is noted that the Diesel uses less fuel (according to Nebraska official tests, 32.3 per cent less, by weight), and a lower priced fuel), than does the gasoline engine and possesses better "lugging ability" at peak load (a capacity which often leads to excessive overloading with concomitantly rapid wear). Those who have successfully used gasoline tractors have no difficulty in operating Diesel tractors. On the other hand, maintenance, due to higher cost of replacement parts, is more expensive than that of gasoline tractors, and the initial cost is higher for the Diesel than for a gasoline powered tractor. "It is evident that the size of the farm or the total number of hours that the tractor is operated each year becomes a deciding factor in the selection of the most economical type of tractor for the requirements of a given farm."

THE LAND IN FLOOD CONTROL. U. S. Dept. Agr., Misc. Pub. 331 [1938], pp. [2]+38, figs. 21. This is a popular account of the problem of flood control and its dependence upon soil, vegetation, and forest conservation, some of the topics taken up being concerned with the role of vegetation in flood control; the extent of vegetal depletion; limitations of vegetal control; the threat of erosion to dams, reservoirs, and other engineering works; procedures under flood-control acts; watershed surveys; nature of watershed measures; and the necessity of teamwork. Pictorial comparisons of good and bad practices are included, together with an appendix presenting the "chronology of flood-control mandates to the Department of Agriculture."

EXPERIMENT IN GRAIN STORAGE, *H. F. McColly.* North Dakota Sta. Bimo. Bul., 1 (1938), No. 2, pp. 6, 7. The author very briefly outlines experiments in progress, the work having included trials of wood and steel bin construction, single- and double-wall wood construction, plain galvanized metal, and perforated metal construction. Wood, perforated metal, concrete, and galvanized iron floors were also included in the tests. Devices for drying and temperature control ventilation have included the use of a silo-filler blower driving air through a drum in the center of the bin, other blower and suction ventilation devices, etc. Temperatures were checked by thermocouples placed in the stored product.

EROSION AND RELATED LAND USE CONDITIONS ON THE REEDY FORK DEMONSTRATION AREA, NORTH CAROLINA, *W. W. Stevens, H. V. Bragg, E. C. Sease, and O. C. Lewis.* U. S. Dept. Agr., 1938, pp. 21, pls. 3, fig. 1, maps 2. A conservation survey of 47,483 acres, mainly in Guilford County, a small part in Forsyth County, is reported.

Erosion is serious in all parts of the area. A total of 87.5 per cent of the land has been subject to accelerated erosion. Damage is slight on 12.5 per cent of the area, moderate on 40.3 per cent, and greater than moderate on the remainder, of 34.7 per cent. An area of 2,239 acres, or 4.8 per cent of the project, has been damaged to such an extent that further tillage is impractical. Most of this erosion has taken place during the last 50 years as a consequence of the clearing of steep hillsides and the spread of intensified row cropping.

Soil conservation is largely a matter of readjusting land use to fit natural conditions. All D slopes (in this survey, over 12 per cent slope, steep and broken) and severely eroded areas should be retired from cultivation. Crops should be grown on the most suitable soils, and crop rotation, strip cropping, contour tillage, terracing, deep plowing, and the use of legumes and cover crops should be generally practiced. These practices, however, are only part of a complete program.

REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL ENGINEERING, 1938, *S. H. McCrory.* U. S. Dept. Agr., Bur. Agr. Engin. Rpt., 1938, pp. 26. "There is strong emphasis on . . . conservation in the work of this Bureau—conservation of crops through better harvesting and through adapting harvesting equipment to new uses of crops; conservation of land already in farms through better drainage and improved drain tile; conservation of water, which in some regions is more valuable than the land itself, through underground storage and more accurate and economical irrigation practices; and conservation of harvested crops through improvements in storages."

The Division of Farm Structures discusses farm building plan exchange, buildings for farm products, potato storage, new silo problems, refrigerator car studies, orchard heating, farm fences, and mechanical cooling of milk. The Division of Drainage takes up hydraulic studies, run-off investigations, drainage of timberlands, durability of drain tile, effect of silage acids on concrete silos, irrigation in the humid regions, drainage of sugarcane lands, water control in peat and muck soils of Florida, C. C. C. drainage camps, maintenance of drainage channels, and flow of water in drainage channels. The Division of Irrigation deals with duty of water, silt in streams and reservoirs, design and invention of apparatus, storage of water underground, snow surveys and irrigation water supply forecasting, flow of water in canals, and customs and laws. The Division of Mechanical Equipment reports upon fertilizer-distributing machinery, corn production machinery, sugar beet production machinery, cotton production machinery, tillage machinery laboratory, harvesting and drying pyrethrum, harvesting sweetpotatoes for starch, pest control equipment, and machinery for weed control. A short section of the report is given to mechanical harvesting of cotton. The cotton ginning investigations of the Bureau have included work on simplification of gins, new developments in cotton driers, fan and piping tests, and gin capacity studies. The report also contains brief statements concerning farm operating efficiency investigations and extension work.

SOME THINGS A FARMER SHOULD KNOW ABOUT ELECTRICITY, *H. L. Garver.* Washington Sta. Pop. Bul. 157 (1939), pp. 40, figs. 19. The terms and materials in common use in general wiring work are defined and described, and elementary applications of Ohm's law are explained. Knob and tube wiring and the use of loom, sheathed cable, armored cable, and rigid metallic conduit are dealt with and the conditions under which each may be suitable are indicated. Information sufficient to permit the work to pass inspection in the State of Washington is given. The wiring of burglar alarms, excess and deficient temperature alarms, and other warning and control devices is also taken up.

Attention is directed to the dangerous possibilities of electrified fences. Until more definite safety standards have been established "the Washington committee on the relation of electricity to agriculture cannot recommend electric fences."

NEW BUILDING MATERIALS, *C. B. Jenni.* (W. Va. Univ.) W. Va. Univ. Bul., 38, ser., No. 3-II (1937), pp. 108-114. The author briefly outlines the nature, method of manufacture, and uses of several of the newer building materials, such as fiber building boards, insulating materials, cellulated clay, gypsum products, fabricated asbestos-cement composition, concrete including prefabricated forms, glass including translucent masonry blocks, synthetic plastics, and metals. *(Continued on page 370)*

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IRRIGATION: A SELECTED BIBLIOGRAPHY, COMPILED BY *D. W. Graf.* U. S. Dept. Agr., Bur. Agr. Engin., 1938, pp. [1]+631. The material is grouped under numerous subject headings alphabetically arranged and, in a second or geographical section, under miscellaneous place names including states of the United States and some similar territorial units, state groups, foreign countries, etc. The compiler has attempted to keep together references to original publications and subsequent reprints, abstracts, or discussions of the original publications. References to books, periodicals, and society publications through 1937 are included.

SOIL EROSION IN THE KARST LANDS OF KENTUCKY: PHYSIOGRAPHIC CONDITIONS AFFECTING EROSION AND LAND USE IN AREAS UNDERLAIN BY SOLUBLE LIMESTONE, *S. N. Dicken and H. B. Brown, Jr.* U. S. Dept. Agr. Circ. 490 (1938), pp. [2]+62, figs. 35. The various types of karst land (the name being taken from that of a limestone area on the eastern Adriatic coast) are described, attention being called to the special forms of erosion induced by gradual solution of underlying limestone with the resultant formation of "solution depressions similar to rude cisterns, hornlike funnels, and broad, shallow basins. Surface watercourses and true valleys are almost absent, since the runoff quickly flows or seeps downward in the hollows and drains away through the extensive underground circulation." It is noted that more than 5 million acres of the southeastern United States farm lands are subject to destructive erosion due to karst land conditions. Adaptations of the usual methods of erosion control to the peculiarities of contour and erosion mechanism which characterize karst lands are discussed. It is noted that much of the Kentucky karst is productive land, but it cannot remain productive under row cropping and other practices not adapted to its specialized conservation requirements.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ALABAMA STATION, 1937, *R. E. Yoder, F. A. Kummer, and E. G. Diseker.* Alabama Sta. Rpt. 1937, pp. 7-9. Progress results are briefly reported of investigations on the physical effects of tillage as related to plant growth, development of reduced friction surfaces and materials for experimental plows, and the dynamics of soil erosion and the principles of control. In the plow studies it was found that among the shapes employing mechanical principles to transport the soil over the moldboard, a plow bottom having a set of eight wooden rollers in place of the moldboard gave promising results. The most effective of all types tried, however, was a slat-type bottom on which the original steel slats were replaced by impregnated wooden slats. Comparative field tests revealed that the wood-slat bottom produced considerably better scouring than the steel-slat bottom, especially in the higher moisture ranges where the "adhesion phase" friction becomes extremely evident.

THE USES AND POSSIBILITIES OF RUBBER IN AGRICULTURE, *A. Hay.* Brit. Rubber Pub. Assoc., Rubber and Agr. Ser. Bul. 8 (1938), pp. [1]+25, figs. 16. This is a compact summary of recent findings relating to the use of rubber in farm machinery, particularly as tires for drive and other transport wheels.

The evidence accumulated from various sources both in this country and abroad indicate that the use of the pneumatic tire for farm tractors and horsedrawn vehicles has led to greater efficiency in farm management. The deeper tread design of the farm tractor tire has proved more suitable for heavier soils and in areas of high rainfall. Larger-diameter tires are recommended for all but the smaller types of tractors. The use of the row-crop tractor with a narrow-section tire and a wheel of increased diameter has been very successful on mixed farms. Six and eight-ply tires are recommended for agricultural tractors. Four-ply tires are only suitable for the lighter soils in areas of low rainfall. Wheel weights or water ballast are advisable as a means of overcoming slip. Antislip devices, including chains, strakes, or girdles, are necessary in areas of high rainfall and on heavy soils. Miscellaneous uses of rubber include horticultural equipment, grading machinery, grain drill tubes, sleeves for potato diggers, rubber blocks in the track construction of roadless tractors, and equipment for the eradication of bracken.

MECHANICAL PROPERTIES OF CERTAIN TROPICAL WOODS, CHIEFLY FROM SOUTH AMERICA, *W. Kynoch and N. A. Norton.* Mich. Univ., School Forestry and Conserv. Bul. 7 (1938), pp. 87, figs. 3. The results of a series of tests on the mechanical properties of nearly 40 tropical woods are presented and discussed. The data, while not conclusive, indicate the probable value of these woods for industrial uses.

FIELD TRANSPORT OF CANE ON STEEL AND RUBBER, *L. A. Tromp.* Brit. Rubber Pub. Assoc., Rubber and Agr. Ser. Bul. 9 (1939), pp. [1]+32, figs. 16. The general trend of field transport of cane is subjected to detailed technical examination in this paper, with particular reference to the use of wheels equipped with steel and rubber tires. It is pointed out that a first condition for field transport is that the compactness of the soil must not be distorted, taking into consideration that the specific soil bearing is different under varying conditions of soil moisture—dry, medium dry, or wet. A second rule is to establish a practical limit to the soil bearing according to climatological conditions, i.e., the wheel or axle loads must be in relation to the wheel rim width, the wheel diameter, and the soil condition. On the basis that rim width is in direct proportion to the allowable wheel load, the conclusion is reached that the larger wheel diameter has a more solidifying action on the soil than the smaller one (less rut formation) for solid wheel tires, and the wheel load increases in direct proportion to the rim width. It appears also that the caterpillar belt causes the lowest specific pressure on the soil of all rolling stock. The analysis indicates further that since the inflation pressure for pneumatic tires is related to the prevailing soil bearing, it follows that for hard paved roads the inflation pressure must be higher than for roads having less specific bearing capacity, i.e., for field roads.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE SOUTH DAKOTA STATION, *R. L. Patty.* South Dakota Sta. Rpt. 1938, pp. 6, 7. Progress results are briefly presented of investigations on field machinery hitches for tractors and large horse teams, corn harvesting machinery, protective covering and the life of steel fence posts, and rammed earth for farm building walls, especially stationary chick brooder houses.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE OKLAHOMA STATION, Oklahoma Sta. (Bien.) Rpt. 1937-38, pp. 149-151. Tests of four types of subsurface drainage for terraces have been made by L. E. Hazen, who also reports on four trials of electrically charged barbed wire for restraining various kinds of livestock, smooth wire having given results in the first test such that it was omitted from the remaining three trials.

PLANS OF FARM BUILDINGS FOR WESTERN STATES. (Cooperative with 11 state colleges and universities). U. S. Dept. Agr., Misc. Pub. 319 (1939), pp. 120. figs. 125. The plans here partly illustrated cover farmhouses and barns of various types; livestock shelters and related structural equipment; granaries and other storages; farm shops; machine sheds; garages; ice houses and other refrigerating structures; and processing and other special purpose buildings, including water storage structures, together with two forms of hay derrick. Working drawings for the construction of these buildings may be obtained at low cost through the county agricultural extension agent or from the extension agricultural engineer at the address of the State college or university.

EXPERIMENTS ON TOXICITY, LEACHING, AND FIRE-RETARDING EFFECTIVENESS OF WOLMAN SALTS, *R. H. Baechler.* (Cooperative with University of Wisconsin). U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1938, pp. [1]+10, figs. 4. The author reports investigations on two preservatives called, respectively, "Tanalith" (sodium fluoride, sodium chromate, sodium arsenate, and dinitrophenol) and "Triolith" (sodium fluoride, potassium bichromate, and dinitrophenol). The toxicity determinations showed that both are very toxic to six typical wood-destroying fungi and have adequate toxicity for wood-preserving purposes.

In the severe leaching tests, the chromium salts proved highly resistant, the total leached throughout the test being only about 1 per cent. About one-fifth of the arsenate leached from the Tanalith treated blocks. The sodium fluoride leached out more rapidly and completely than the other salts, the average proportion leached falling between 70 and 80 per cent of the amount originally injected. It was found that the leaching of sodium fluoride from Triolith treated blocks started at a slower rate than from similar blocks treated with sodium fluoride alone, although the total leached at the end of the test was approximately the same.

When the leached blocks were exposed to fungus attack in Kolle flasks, it was found that the leaching had been carried so far that they were not immune to attack but, against all but one fungus, they showed much greater resistance than the untreated control blocks. The fungus *Lenzites trabea,* known to be arsenic tolerant attacked the leached Tanalith treated blocks about as severely as it did the untreated blocks.

Lumber treated with from 0.79 to 0.88 lb of Wolman salts per cubic foot of wood showed no significant resistance to fire in the Forest Products Laboratory fire-tube test.

Literature Received

"FARM SHOP PRACTICE," by Mack M. Jones. XIII+315 pages, 6x9 in, 360 illustrations, clothbound. A text designed to supplement discussion and demonstration, and a reference for review purposes. Chapters under farm woodwork and carpentry cover measuring and marking, sawing, planing and smoothing, wood chisels and their use, boring and drilling holes in wood, wood fastenings; use of modeling or forming tools and shaping curved or irregular surfaces; painting, finishing, and glazing; and cutting common rafters. Part II, on tool sharpening and fitting, includes chapters on tool sharpening, grinding and sharpening equipment, and saw sharpening. Under cold-metal work are chapters on general bench and vise work, drilling tools and their use, and bolt threading equipment and its use. Farm blacksmithing is covered in chapters on blacksmithing equipment and forge fires, fundamental forging operations, forging and tempering tool steel, and welding, plow sharpening, and kinds of iron and steel. There are additional chapters on pipework, soldering and sheet metal work, farm concrete work; harness repair, belting, and belt lacing; and ropework. McGraw-Hill, $2.75.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted."

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted for an opening in prospect as instructor in farm structures and machinery at the New York State Institute of Applied Agriculture, Farmingdale, Long Island, New York. Applicants should write directly to A. A. Stone, head, department of rural engineering at this institution, giving full information about their educational training and professional experience.

STUDENT AID IN ENGINEERING. The U. S. Civil Service Commission announces an assembled open competitive examination for student aids in the Department of Agriculture, with engineering as one of eight optional subjects. Appointees will be subject to a period of training which will combine instruction concerning the objectives and procedures of the service with practical work in various field activities. Promotion to higher grades in the subprofessional service or to junior professional positions will depend on the occurrence of vacancies and upon the individual record of the appointee, subject to such noncompetitive examination as the Civil Service Commission may prescribe. Applications must be on file with the Commission at Washington, D. C., not later than September 25, 1939, or for those mailed from several named states in the far West, September 28, 1939. Application form 8, copies of which may be obtained at any first-class post office, should be used in filing application for this examination. Applicants must not have passed their 30th birthday by the specified closing date for receipt of the applications, and must have completed at least three years of college study in engineering, the completion of the third year being subsequent to May 1936 and previous to the closing date for applications. Other usual Civil Service examination regulations apply. More detailed information is given in the Commission's announcement No. 90 dated September 5, 1939.

POSITIONS WANTED

AGRICULTURAL ENGINEER with bachelor's degree and a farm background, desires position as agricultural engineer for electric power company. Has one year's experience with the sales and service branch of a large farm machinery company, and four years' experience as assistant county agricultural agent in soil conservation and engineer in charge of a large terracing unit. Has had considerable experience in contacting farmers and helping to solve their problems. Has a real sales record, Age 39. Married. PW-305

AGRICULTURAL ENGINEER and FARM MANAGER with bachelor's degree, farm management, marketing and extension background, desires enterprise management, supervisional, sales, educational, or demonstrational work. Has had 14 years experience as manager of 1,000 acre citrus development including growing, harvesting, packing, canning and marketing citrus fruits; 4 years agricultural extension specialist in farm management, soils, irrigation, alkali reclamation, and field crops. Age 42. Married. PW-307

AGRICULTURAL ENGINEER, 1939 graduate with a bachelor's degree and a farm background, desires a position in any field of agricultural engineering. Age 23. Single. PW-308